MATERIALS & METHODS

THE METALWORKING INDUSTRIES' ENGINEERING MAGAZINE

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Hard Chromium Plate and Its Uses

Permanent Mold Gray Iron Castings

The Safe Handling of Solvents

Drying Industrial Finishes on Metals

Induction Heating Applied to Steel Gears

Precision Grinding

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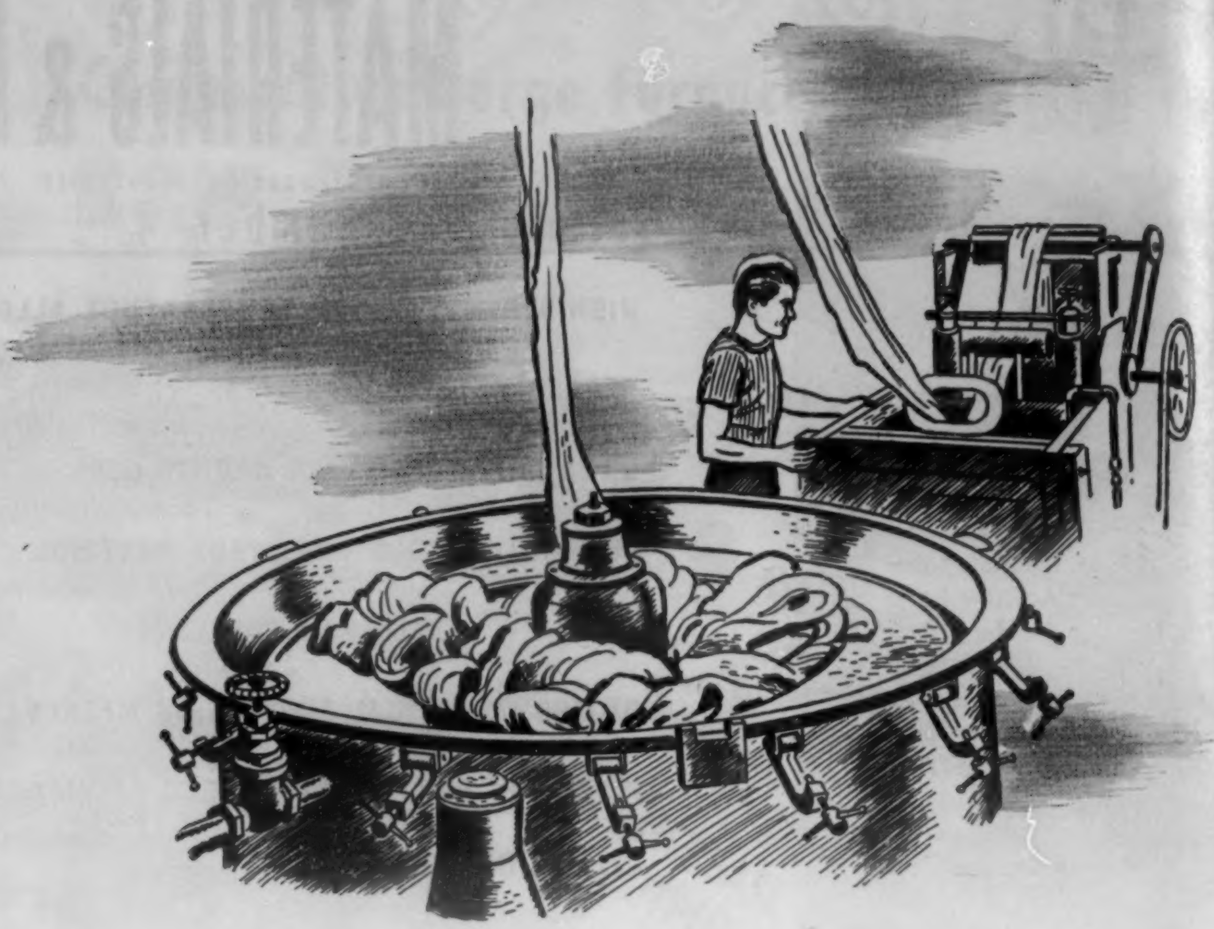
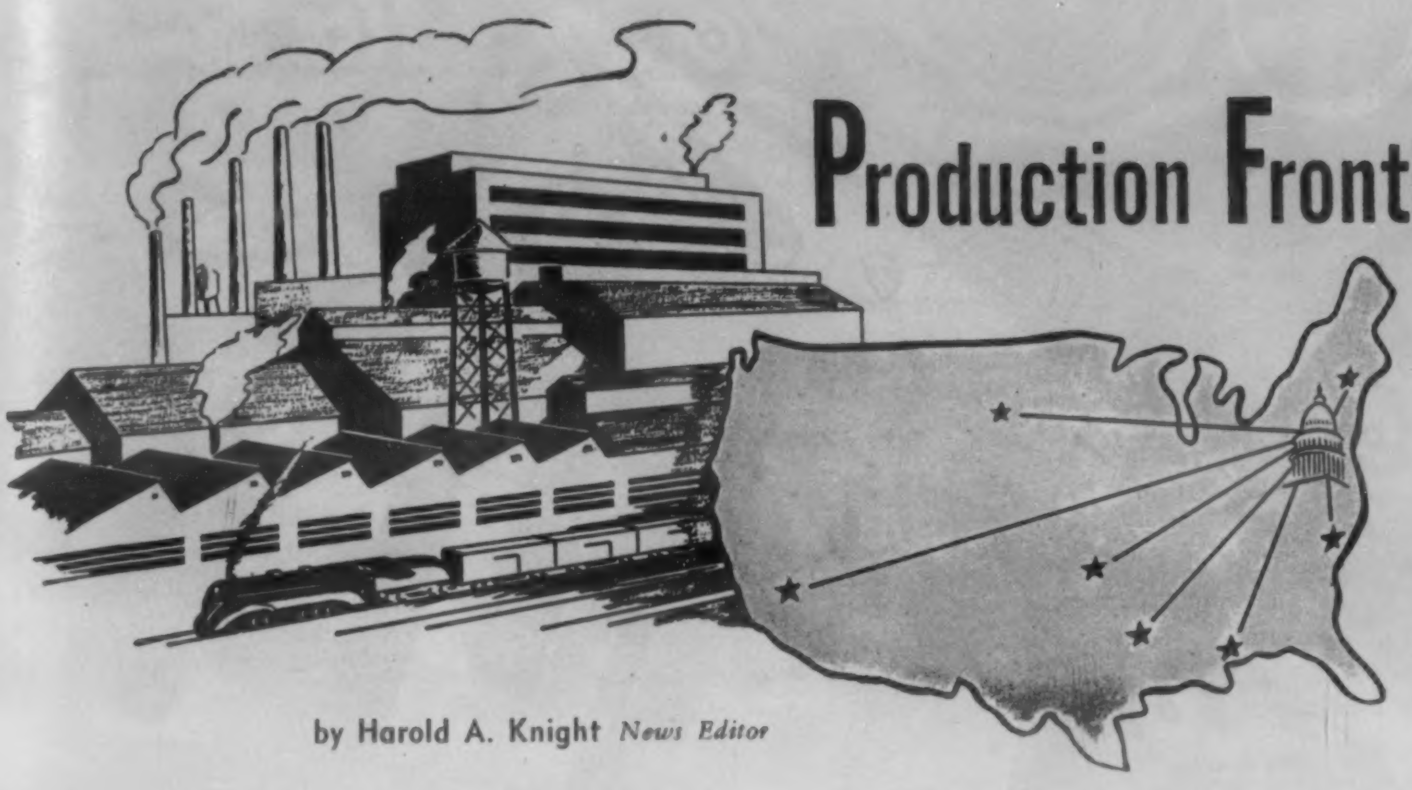
Universal grinders find a wide variety of applications in today's precision metalworking shop, as is pointed out in this month's "Materials & Methods Manual." This photo shows a Brown & Sharpe universal grinding machine in action.

NEXT ISSUE:

Seventeen articles describing those achievements winning awards and citations in MATERIALS & METHODS ACHIEVEMENT AWARD COMPETITION
and
PREVIEW OF THE NATIONAL METAL CONGRESS AND EXPOSITION





Production Frontiers

by Harold A. Knight *News Editor*

"Situation" Has Seemed to Be Marking Time

Usually we are not at a loss for a keynote on which to launch this exposition on "the situation" as we see it. There is invariably some phase of American economics and industry fairly crying out loud to be dealt with by a trenchant and vitriolic pen. Perhaps our thoughts are too much on our coming vacation.

It may be, of course, that we are like the cub reporter who was given his first important assignment—the covering of a wedding between two blue-blood families of the city. Hours passed and the editor found the cub in a back room playing penny ante.

"What about that wedding?" asked the editor, with eyebrows arched a bit more than usual.

"Oh, there wasn't any wedding," answered the cub, eyes still concentrated on the cards. "The bridegroom didn't show up."

Just then the newsboys were shouting headlines from the rival newspaper: "Bride Left Waiting at the Church — Groom, Percy Proudfoot, Doesn't Appear!"

Perhaps we just haven't looked far enough for that keynote. Perhaps we have merely been playing penny ante these past few days. We will say in defense that Congress has adjourned, with the Kentucky congressmen drinking mint juleps among the homefolk, the West Virginia boys sampling the first brews of the season of apple cider. Washington hotels are actually looking for guests.

One of the few things that has caught our eye is a study made by the Guaranty Trust Co. as to how capital and labor fare in their sharing of the consumer's dollar. According to the Guaranty study, the return to labor in 1944 was nearly three times the return to capital before income taxes and nearly seven times the return after income taxes. Of each dollar of corporate production in 1944 employees received 61 cents, overhead amounted to 11½ cents, taxes were 18½ cents, and net profits 9 cents.

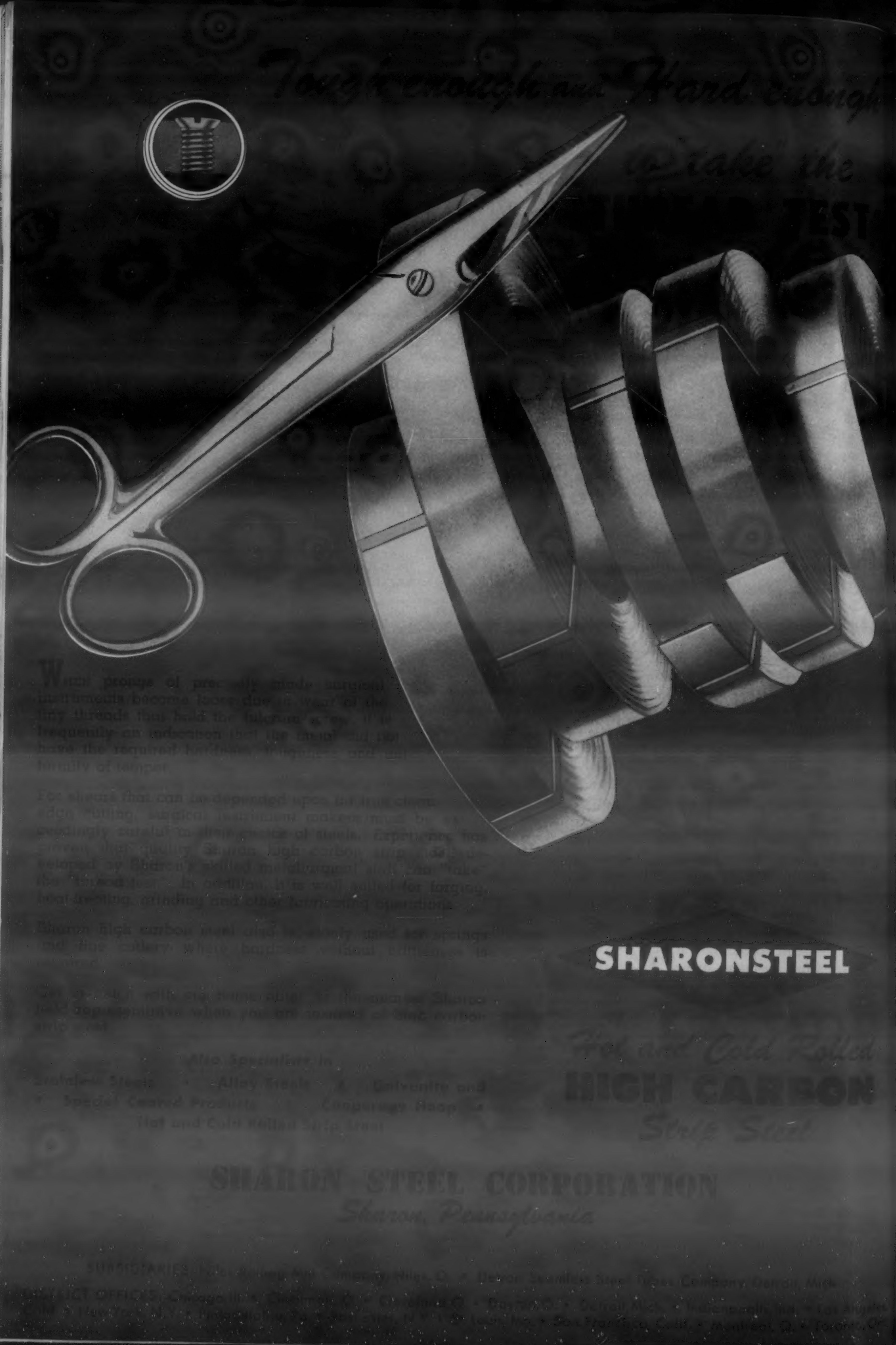
Can't Get Away From Production Need

It is a petty man indeed who begrudges labor good real wages and the full life which is the American way. However, the workman must be worthy of his hire, and a full day's work must be given for a full day's pay. Previously in this publication we have pointed out some unnatural movements, such as shipping half-finished work outside the country by airplane for further processing where labor is cheaper—then flying it back again.

We hear from many sources now that labor-saving machinery is on drawing boards and on skids and pallets ready to be installed as never before because of high labor costs. Only recently we visited a plant of the Revere Copper & Brass Co. at Rome, N. Y. They pointed out a materials handling gadget, "The Porcupine," which they said was novel to copper and brass manufacture. It loaded brass slabs into the rolling mill automatically. It displaced 30 men, but fortunately the 30 were taken care of in another part of the plant. But, of course, this replacement of labor, if it comes too suddenly and universally, upsets the employment situation seriously. We are not one to fight against real progress and the doing by machine what was formerly done by hand.

We are against, however, too exaggerated and too accelerated movements. We fear that the further mechanization is coming about too rapidly and abruptly and will sooner or later cause widespread unemployment. We fear that the continually higher wage rates, abetted by Washington and the Wagner Act, will have very serious repercussions.

As we write we gradually crystallize our thoughts and find that for another month the keynote is need for large production. A savant and


SHARONSTEEL
Hot and Cold Rolled
HIGH CARBON
Strip Steel
Also Specialists in
SHARON STEEL CORPORATION
Sharon, Pennsylvania

scholar who has talked on this subject recently is Dr. Willard H. Dow, who states that only through a widespread improvement in labor efficiency can inflation be checked. "Inflation," he philosophized, "is a symptom of human desire not to work and produce. Improved manpower efficiency quickly reduces costs and results in greater production. Conversely, low efficiency results in higher costs and scarcities, with the consequent spiral of inflation, bread lines and general hardship for everyone. The will to work is the blessing we sooner or later must recognize as the only solution to all our man-made problems. Produce more—have more. That holds true for a single individual or a nation of millions.

"It is a notorious fact that manpower in general is at about the lowest efficiency it has ever been," Dr. Dow bluntly stated.

For four years we have dealt much with scarcities in these columns. Probably at the moment the lack of pig iron most frequently makes the business news columns. This is the more serious because of the twin scarcity of iron and steel scrap. Many foundries are operating at only 35 to 50% of capacity because of inability to get iron. Some of the difficulties can be traced back to the coal and railroad strikes earlier this year.

In other times of pig iron scarcity here, relief has come from imports of foreign pig iron, such as from Holland. Such imports are now out of the question in view of the devastated conditions of Europe. The iron shortage promotes the use of substitute metals, such as magnesium castings in the place of cast iron. It will be interesting to see how many substitutes last when iron is plentiful again.

Iron Powder at Logical Source

The American steel industry became great because our leading steel making centers were built where more than one raw material was available. In Alabama iron ore and coal are both handy. What looks like another important and logical step is the building of a plant to make 99% plus iron powder at the very mines of the Mesabi range in northern Minnesota.

The new plant, which will turn out 5 tons of iron powder per day, will use as raw material iron carbonate slate, heretofore a waste product, which overlies the iron ore formation and is present in great abundance. In a continuous chemical process, susceptible to close control, the iron is dissolved out of the ore by acid, precipitated as crystals of iron sulphate and preferentially roasted to iron oxide of high purity. This is then reduced to iron powder of controlled physical characteristics.

"Joyce, did anyone ever tell you that your eyes sparkle like our Number 72 metal?"

Engineers in charge are confident that the process can yield a pure product at a cost that will result in greatly expanded use of iron powder. Continental Machines, Inc., has contracted to operate the plant, which is being built by the State with funds appropriated from the tax on mining iron ore. The conversion process was developed by the late Charles V. Firth at the Mines Experiment Station of the University of Minnesota.

Fabricators of iron powders will watch with keen interest to see what the physicals of the new powder are, what the selling price will be, and what the degree of uniformity of product. A recent survey of users of iron powders revealed that the customers want a better quality of the low-price irons and a lower price for the high quality powders.

Present consumption of iron powder is estimated by an undisputed authority as 6 or 7 tons per day, hence the new plant should nearly double present apparent capacity.

But whatever the niche into which this new powder falls, at least the new plant seems logical as to site and modus operandi.

Go Southwest, Young Man

Ohio's industrial growth is slowing down in relation to the nation's total gains despite a good war production record. This statement was not made by the Los Angeles Chamber of Commerce nor by any "Senator Claghorn" from the South—but indeed by Ohio State University's Bureau of Public Relations from a study by Prof. Alfred J. Wright of the geography department.

Ohio still gains industrially, but not at the same rate as for the nation as a whole, says the learned professor. Major shifts, as to Ohio, have been in farm implement and clay and earth-moving machinery from Ohio to Illinois, West Virginia and California. Shifts in manufacturing have stimulated greater industrial vigor in Michigan and Illinois, while Wisconsin, Ohio and Indiana have lost some vitality. West Coast States, notably California, made large wartime strides, though mostly in war goods. California will keep part of its gains.

"If any part of the country forges a permanent type of industrial progress," states the professor, "it would probably be the Texas-Oklahoma West-South-Central region where sales of war plants for peacetime production have been considerable."

So, returned G. I., go Southwest, young man!

More Power to the Russians

One of the interesting engineering enterprises of the war, concerning which but little publicity has emanated, were the 63 power trains, of ten cars each, built in the United States and sent to Russia during the thick of the fighting.

Thus, Stalingrad was a shambles after the German bombardment with Stukas and heavy artillery of many calibres. On June 1, 1944, Lt.-Gen. Rudenko was presented with the first power train to provide heat, light and power so that Stalingrad might become in some measure a "going concern" as a city and serve as a stepping off place for counter-attacks against the Germans.

Forty mobile power plants of 3,000-kw. capacity were built, each consisting of 9 or 10 cars, depending on the method of cooling. Two were boiler cars, capable of burning low grades of Russian coal, each boiler capacity being 24,000 lb. of steam per hr. Coal and water were carried on two tender cars similar to those of standard locomotives. Portable unloaders and conveyors handled coal and ashes. The turbine car contained a 3-phase turbine-generator, delivering at 6,300 or 11,000 v. The switchgear car consisted of three oil circuit breakers, one generator circuit and two feeder circuits. There were two or three cooling cars per train.

One car was partly for sleeping accommodations of the crew and partly as a maintenance room and test laboratory. Among the American major contributors to the power trains were the General Electric, American Locomotive, Baldwin Locomotive, Babcock & Wilcox, and American Car & Foundry companies.

Such trains might well be used in the United States as standby emergency equipment for disasters in this country from hurricanes, cyclones, floods, fires, etc.

Edison Class Engineering Problem

A score of years ago Thomas A. Edison devised a list of questions to test mental and other qualifications of young men who applied for jobs at his firm. Some of the questions involved actual knowledge or memory of facts; others called for logical reasoning and common sense in solving a problem.

We recall that one question was substantially such as this. Engineers, with meagre equipment, wish to take steps to span a deep chasm, at the bottom of which is a river, with a bridge. What is the best simple equipment to start operations? As we recall the answer, it was a coast guard's gun with which he shoots a line to a foundered ship.

Another problem which might well have been included on the list was in the form of a news item in the New York metropolitan newspapers a few weeks ago. A 60-year-old Brooklyn woman, weighing 280 lb., got stuck in her "old-fashioned zinc bathtub" and was there for 17 hr., having passed 13½ hr. alone before her plight was discovered. Somebody was working on her for 3½ hr., but the new Edison employee of 20 years ago would have had to do better than that.

The police finally extricated her by oiling the side of the tub. We once extricated a stuck mouthpiece from our trombone by squirting glycerine around it.

But to get back to the woman, how would you, an engineer, have extricated her? As one suggestion, pour down ice tea and heat the outside of the tub.

The columns of this department are open to the most practical suggestion, to be passed along to the Brooklyn police.

This contest is not to be confused with the "M & M Achievement Award."

In Best Demand: Our Know-How

"U. S. Know-How" is a highly salable product and perhaps in greater demand abroad than our raw materials or finished manufactured goods. Here is a typical instance of a big deal that has already been made. Westinghouse Electrical International Co. has contracted with an agency of the Chinese government to build a $35,000,000 electrical products manufacturing plant in China. Westinghouse engineers will design the plant, draw up machinery specifications and train personnel.

The company will receive a lump sum payment for its services during the first 10 years of the plant's operation and, during the next 10 years, will receive royalties on sales.

As William E. Knox, President of Westinghouse International, says: "The basic part of the Westinghouse foreign trade philosophy is the making of American technical know-how available to foreign countries to help them help themselves."

Chit Chat Re This and That

Atomic energy, when harnessed for peace, may be employed in such bizarre tasks as irrigating the Sahara Desert and melting the ice cap on Greenland, it was predicted by Harry A. Winne, vice president, General Electric Co., in charge of engineering policy. Both have been mentioned, not only as reclamation projects but also to regulate weather conditions. However, most people don't realize the amount of energy needed to melt ice, states Mr. Winne. The heat necessary to melt 1 gal. of ice would, if converted into pumping power at only 20% efficiency, lift more than 200 gal. of water 100 ft.

An interesting use for American steel pipe was the making of gun barrels by Philippine guerrillas for killing Japs. One such gun was found made of ¾-in. standard Youngstown Sheet & Tube Co. pipe. It was a crude hand-made 12-gage shotgun which had apparently seen plenty of service. A picture of the gun will be used in advertising of the Youngstown Company.

Most everything these days is "packaged" this and "packaged" that. The builder of a new house can buy a "packaged kitchen" for instance. Now comes the "packaged manufacturing plant" for export to foreign manufacturers. The plant is a complete production unit, including building and all necessary machinery, prefabricated and ready for re-erection in the shortest possible time. Service on the spot for several months goes with the "package." The entrepreneurs are the Intercontinental Engineering Corp., 110 Market St., San Francisco 11.

An East-West compass to suit the radio character, Senator Claghorn, is a reality, reports General Electric's *"News Digest."* (That's no joke, son!). It will not point to the hated North where the damn Yankees live. It is made of "Silmanal," which has receptivity to be magnetized sideways rather than lengthwise—though no practical use has yet been found for such a compass. Silmanal's chief advantage is its extremely high coercive force, which permits it to withstand severe demagnetizing effects. Because of this high resistance it is useful in electric relays and in instruments where service in strong electric fields is required.

The interpretation of Harry S. Truman's handwriting by an expert is "simplicity, balance and persistence." His penmanship is that of stable and mature persons whose interests are almost evenly divided among mental, spiritual and practical considerations of everyday living. So states a recent book on "Handwriting" by Henry O. Teltscher, published by G. C. Putnam's Sons.

Engineers — Companies — Societies

Engineers

Dr. Reginald S. Dean, head of the Metallurgical Div., U. S. Bureau of Mines, has left that Bureau after 17 years' service to engage in private practice as a metallurgical engineer and consultant specializing in electro-metallurgy and alloys, with offices and laboratory at 2041 K St., N. W., Washington. Under Dr. Dean's direction the Bureau's laboratory facilities were expanded from a few minor installations at various universities into a group of the finest metallurgical laboratories and pilot plants.

James L. Erickson, contributor to MATERIALS & METHODS and former associate editor of *Die Castings,* has joined the Pryor Mfg. Co., Mansfield, Ohio, as assistant to the president.

Emil G. Holmberg has been appointed consulting metallurgist for Alloy Steel Products Co., Linden, N. J. A graduate of the Colorado School of Mines, he was research metallurgist, specializing in corrosion problems, at the Belle, W. Va., plant of the du Pont Co.

Charles G. Purnell, who developed a method of quenching and tempering hardenable steels during his 19 years with Carnegie-Illinois Steel Corp., has joined Cabot & Co., Inc., Pittsburgh advertising agency. He has delivered many papers before technical societies and written for the technical press on quenching and tempering.

Thurston C. Merriman has become consulting metallurgist for the Phosphor Bronze Smelting Co., Philadelphia 46, having formerly been metallurgist for the Seymour Mfg. Co. Other experience was with the American Brass Co., Winchester Repeating Arms Co. and Western Electric Co.

Quentin D. Mehrkam, formerly production metallurgist with Thompson Products Co., Cleveland, has joined the metallurgical staff of the Ajax Electric Co., Inc., Philadelphia manufacturer of electric salt bath furnaces. He will be engaged in developing new processes and experimentally heat treating manufacturer's specimen work in the company's research laboratory.

Hugo Hiemke has joined the Pacific Coast Div., A. O. Smith Corp., as assistant director of the company's laboratory in Los Angeles. For the past year he has been research supervisor for the War Metallurgical Committee, National Research Council.

Dr. Clarence F. Hiskey, former laboratory director for the 43rd Army Chemical Laboratory Co. in Hawaii, has joined the chemistry department, Polytechnic Institute of Brooklyn, to teach analytical chemistry and do fundamental research. When working for his doctorate at the University of Wisconsin, he specialized in rhenium, molybdenum and other rare metals. He will now explore rhenium for the television and electronic fields.

The Aetna-Standard Engineering Co. has appointed *Astor L. Thurman* assistant to the vice president. He has a broad background in electrical and mechanical engineering fields, and has authored articles on draw benches, wire drawing machines and tube mills. Aetna has also made *James Riddell* chief electrical engineer. Previous associations have been with Great Lakes Steel Corp. and Republic Steel Corp.

Warren H. Farr has been made vice president in charge of manufacturing of the Budd Co., having been in the production department of that company for 19 years.

D. E. McGuire has been made chief engineer, Great Lakes Steel Corp., having been assistant to the general works manager.

John O. Forster has been made chief engineer, Aircraft Screw Products Co., Inc., having formerly been chief engineer for Bulova Watch Co. He is thoroughly experienced in the design of precision mechanical assemblies.

Dr. William L. McCracken, formerly lieutenant colonel, Army engineers, has been made administrative assistant to the vice president in charge of research and engineering, Detrex Corp., Detroit.

Robert T. Sammet has become director of research of the Mitchell-Bradford Chemical Co., Bridgeport, Conn.

Maurice D. Bennett has been made superintendent of research for the Stamford Div., Yale & Towne Mfg. Co. *Fred K. Heyer* will direct general research on locks and hardware in the research department.

Warren R. Purcell has been made manager of quality control, Lamp Div., Sylvania Electric Products, Inc. He is president of the Boston Society for Quality Control.

Robert T. Pursell, formerly welding engineer, Worthington Pump & Machinery Co., has joined the Charles W. Krieg Co., Newark 4, N. J. During his 15 years in the welding field he has delivered many lectures on welding and radiography, and has been prominent in technical societies in those fields.

Melvin Shaulis has been made assistant superintendent, Brier Hill blooming and round mills, Youngstown Sheet & Tube Co., having joined the company in 1933.

C. H. Welch has been appointed plant manager and *J. E. Gickler,* superintendent, Alloy Cast Steel Co., Marion, Ohio. The former was plant engineer, Commercial Steel Casting Co., Marion, while Mr. Gickler has been assistant superintendent of Alloy Cast Steel since 1942.

R. E. Wagenhals, formerly quality control engineer, has been made director of quality control for all bearing divisions of the Timken Roller Bearing Co., having joined the company in 1943.

Correction

J. F. Brooker has been made assistant superintendent of the forge department, Canton plant, Barium Steel & Forge, Inc., having formerly been night superintendent, Johnson & Jennings Co. plant in Cleveland. He will also be in charge of the hammer shop.

Through an error, a previous announcement of this appointment in MATERIALS & METHODS listed the name of *G. W. Shetler* as assuming this position. Mr. Shetler, who is vice president of Barium Steel & Forge, Inc., made the announcement.

Companies

Handy & Harman, New York, is building a new plant in Los Angeles to more completely serve the increased demand for gold and silver, as well as refining service, on the Pacific coast.

International Harvester Co. is setting up a manufacturing research laboratory at 5225

(Continued on page 1042)

Meetings and Expositions

ELECTROCHEMICAL SOCIETY, fall meeting. Toronto, Ontario, Canada. Oct. 16-19, 1946.

AMERICAN SOCIETY OF BODY ENGINEERS. Detroit, Mich. Oct. 23-25, 1946.

PORCELAIN ENAMEL INSTITUTE, annual meeting. French Lick, Ind. Oct. 23-25, 1946.

SOCIETY OF AUTOMOTIVE ENGINEERS, national fuels and lubricants meeting. Tulsa, Okla. Nov. 7-8, 1946.

AMERICAN SOCIETY FOR METALS, annual meeting. Atlantic City, N. J. Nov. 18-22, 1946.

AMERICAN WELDING SOCIETY, annual meeting. Atlantic City, N. J. Nov. 18-22, 1946.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Iron & Steel and Institute of Metals Divisions. Atlantic City, N. J. Nov. 18-22, 1946.

NATIONAL METAL CONGRESS AND EXPOSITION, Atlantic City, N. J. Nov. 18-22, 1946.

AMERICAN INDUSTRIAL RADIUM & X-RAY SOCIETY, annual meeting. Atlantic City, N. J. Nov. 19-22, 1946.

AN EDITORIAL

One Year of "Materials & Methods"

This is the first anniversary of "Materials & Methods" as the new name for this magazine, and certainly an appropriate time for us respectfully to submit to you a report on the state of your magazine and especially on how well we have fulfilled our promises made a year ago.

In announcing the new name in our October 1945 issue, we explained that over a 5-year period we had evolved an editorial policy of serving a specific function in the metalworking industries, the function of selecting and processing the engineering materials used in manufactured products. We declared that the introduction of the new name involved no change in that established policy, but merely a more accurate labeling of it; we vowed this was "a change in name only." And we promised to continue to improve your magazine in keeping with its position as the only journal specializing in complete and up-to-date information on engineering materials and their processing available today. Well, how have we done?

1. As we promised, we have remained (and will remain) a magazine for the metalworking industries (the industries manufacturing mechanical, electrical, transportation, and other fabricated products and parts). We have not run articles on drapery materials, rugs, bed linen and men's clothing as a few pessimists feared we would.

2. The proportion of our editorial space given to metallic materials on one hand and to nonmetallic materials on the other, has remained approximately at its October 1944—September 1945 level, and continues to reflect accurately the relative importance, tonnage-wise, of metals and nonmetallics as raw materials for the products of the metalworking industries. During the past twelve months 12% of our articles have dealt with nonmetallic engineering materials; in the preceding twelve months the corresponding figure was 10%. Plainly, we have not abandoned our interest in metals as the most widely used materials of construction.

3. The changes in the magazine that *have* occurred during the last twelve months have been largely improvements in the service already being offered rather than revisions in its basic nature. During the past year we published 120 feature articles and Manuals, as compared with 96 in the prior twelve-month period. The quality of paper and the trim-size of the magazine were restored as soon as possible. The typographic appearance of the magazine was improved by the judicious use of color and other aids to readability. The size of the editorial staff was increased from 4 men in 1945 to 7 men today, making our coverage more widespread, more alert and more unbiased (since a larger proportion of our material can now be written by staff members) than ever before.

Also, we have emphasized feature articles on *new developments* in materials and processes to such an extent that not only our readers but also developers and manufacturers of new materials have come to regard this magazine as the natural and obvious place in which to find or to make the first feature editorial announcements of new developments in the materials field. Thus, during the past twelve months, fourteen such "new materials" feature articles have appeared (10 on alloys and 4 on nonmetallics) and in a questionnaire-survey of our readers just concluded, this type of article was enthusiastically voted as the most popular of all the types of feature articles we might publish.

Finally, we have been most gratified by the overwhelming favorable reaction to our whole editorial program as it has been underlined and emphasized by our new name. The first year of "Materials & Methods" has proved that there was a long-existing need for a magazine concentrating on the selection and processing of engineering materials and that this magazine is filling that need very nicely.

But we're a long way from perfection. You've helped us immensely in the past few years to understand and to meet your informational needs. We can continue to improve our service to you and to keep all materials and process engineers informed on the latest and the best only with your continuing help. We'll be just as grateful for your future aid as we are now for all your past assistance—and especially for your support during what could have been a troublesome year under a brand new name.

FRED P. PETERS

Editorial Comment

The Productivity Picture

Productivity is a mighty important word in the country's economic vocabulary, especially these days when there is a demand everywhere for more and more goods. At the present time labor is being accused of restricting productivity, and the accusation is a just one. The records are clear: labor is, for various reasons, slowing down on the job. But we should not let the widespread and vehement denunciation of this slump in labor's output crowd out the other factors that go to make up the productivity picture.

In the long run, productivity is not wholly dependent upon one group or on one element in our complex industrial structure. Productivity is a result of the sum total effort of all the groups entering into the production of goods. These are capital and management, engineering, and labor. If any one of the elements fails to function properly our productivity suffers a set-back. As can be seen from present day events, labor can restrict the productivity of the country by feather-bedding practices, strikes, opposition to industrial mechanization, and demands for excessively high wages. The owners of industrial enterprises and their managers can also restrict the productivity. They can curtail output to keep prices at a sufficiently profitable level; they can refuse to replace outmoded equipment with new and faster producing machinery; and they can withdraw or withhold their capital from fields of industrial production as they see fit.

The engineers are unique in two very important respects from all the other groups which together produce the goods under our economic system. They are the only group who by education, training, and tradition strive at all times for maximum productivity at the lowest possible cost. They are not preoccupied like labor and capital with the desire to influence or control productivity for their own immediate benefit. Their only concern is to increase productivity: select the best and most economical materials; devise the most efficient means of processing those materials; and see to it that industrial operations, once started, function properly.

The engineers are also the only group who devise the actual means of increasing productivity. Even though labor, capital and management desire to increase production, the technical group must implement industry with the mechanical equipment and process refinements to increase output.

So, in the productivity picture, the engineering group is somewhere in the middle between the conflicting interest groups: labor on the one hand demanding higher wages and producing less; owners and management on the other hand holding down productivity wherever it threatens to cause price reduction below that which will give a "reasonable" profit.

Somehow, in spite of this interference and with the sporadic cooperation of all the groups, our productivity over the years has steadily increased. No small share of the credit goes to the engineers. And to them goes the responsibility of increasing productivity in the future. As time goes on and our industrial system grows more and more complex, the technical group will increase their influence over our productive activities. Should they some day be able to use their technical knowledge freely and unhampered, the productivity of the country would increase to heights never dreamed of before.

—H. R. C.

The Stainless Steels

That the stainless steels have reached new heights as engineering materials is amply confirmed by the production data of American producers, compiled by the American Iron & Steel Institute. A new record total for these steels for 1945, at 542,904 net tons of ingots, was achieved—the first time the 500,000 mark has been exceeded or approached. In 1934, when these annual data were first published, this total was only 55,907 tons—an impressive expansion in 12 years.

Two other facts may be selected among these 1945 data as both interesting and significant. The Institute classifies the data into four types—18 and 8, 12 to 14% chromium, 16 to 18% chromium, and "all other" chromium and nickel-chromium compositions. The leader of these last year, as in all other years, was the 18 and 8 type, which passed for the first time the 300,000-ton total at 314,882 tons. This is the most popular stainless steel and is applied to more uses than any of the others.

The plain chromium types about held their own, but there was a large increase in the "all other" alloys. Last year the 91,210 tons exceeded any other year in this classification, indicating the growing expansion in these special alloys and their diversified engineering applications. Probably a few of these are high temperature alloys as some stainless steels are used in jet planes.

The expansion in production and engineering applications of the stainless steels was predicted in the early history of these materials. This prediction is justified by the fact that the production has increased about 87% since 1934. The growth in their popularity and use will continue to new heights, though it may not reach the proportions of the last decade or so.

—E. F. C.

Production: Distribution Ratios

The Department of Commerce sponsors a new organization called the National Distribution Council which is concerned with the distributive mechanism of the nation. Doubtless most of our readers are concerned with production, yet distribution and service take on where our readers' work ends, and it perhaps is well to be posted on activities so closely related to production.

It is a case of about one-third of us keeping posted on what one-half of us are doing for, according to the last census figures, properly analyzed, those engaged in gainful employment in manufacturing in 1930 comprised 30.9% of our working population against 47.2% in distribution and service. The other 21.9% was in agriculture.

We heard Raymond Bill, a fellow publisher and chairman of the new National Distribution Council, explain the functions of the new organization in Washington recently. He presented the following brief table from which we have already quoted, pertaining to employment as to major industrial classifications, in per cent:

	1870	*1920*	*1930*
Farming	53.5	27.6	21.9
Manufacturing	21.9	32.9	30.9
Distr. and Service	24.6	39.4	47.2

It is to be noted how in our early days the majority percentage was in agriculture; further, how in the decade from 1920 to 1930 percentages dealing with the production of things fell off (be it farming or manufacture) at the expense of distribution and service.

The same trends, states the speaker, are observed for Great Britain, New Zealand and Australia, all countries where standards of living are high.

So, reader, assume you have four children: One son will normally go into agriculture, one son into a manufacturing plant, but one son and a daughter will be in distribution and service—a different lineup from your grandfather's family! —H. A. K.

We Don't Like "Quotas" Either

There are times when steel buyers must be on the verge of going berserk at the sound of the word "quota." We don't like quotas either . . .

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THE METALWORKING INDUSTRIES' ENGINEERING MAGAZINE

High Strength, High Temperature Alloy S-816

by THOMAS Y. WILSON, *Research Staff, Allegheny Ludlum Steel Corp.*

High strength at 1500 F, resistance to burned fuel gases and ease of fabrication are among the favorable characteristics of this new alloy.

HIGH STRENGTH STEELS for operation in temperature ranges exceeding 1100 F have long seen service as furnace parts, internal combustion engine exhaust valves, and wheels and buckets for gas turbines. Research to improve these steels and to develop better steels for these purposes has been carried out by the Allegheny Ludlum Steel Corp. for many years. However, when engineering development showed the possibilities of gas turbine and jet propulsion motors for aircraft if steels with far greater high temperature strengths than had previously been known were available, the tempo of research was stepped up to meet this urgent demand. While high strength and creep resistance are primary considerations for such applications, resistance to the corrosive action of fuel combustion products is of no less importance. Judging from past experience, it was known that alloys possessing the desired characteristics would be of a complex structure, possibly unresponsive to hot working and forming operations.

As a result of this intensive research, Allegheny Ludlum Steel Corp. has developed a number of alloys which possess unusual strength up to 1500 F, are responsive to most fabricating operations, and are resistant to burned fuel gases. The alloy of greatest strength has been designated as S-816, while other useful alloys possessing slightly lower strength and

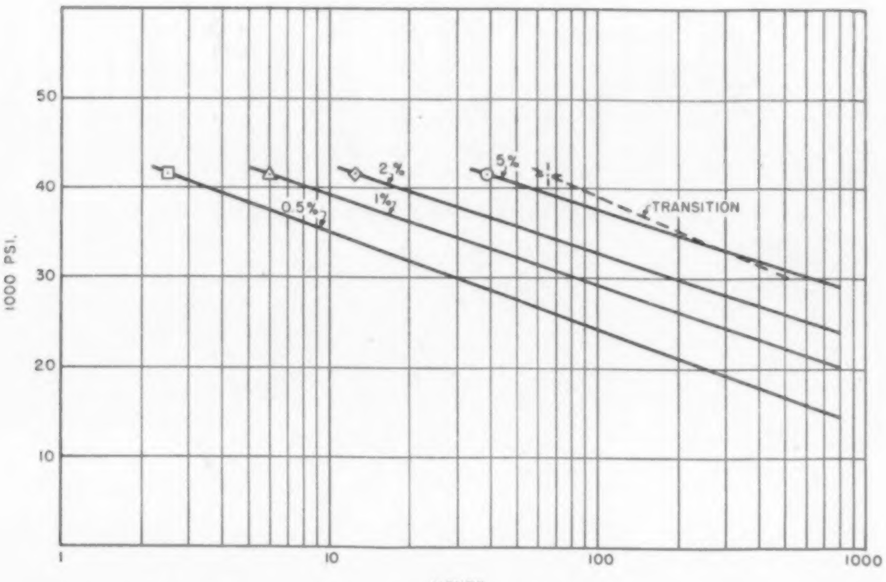


Fig. 1—S-816 1350 F design curves, approximate.

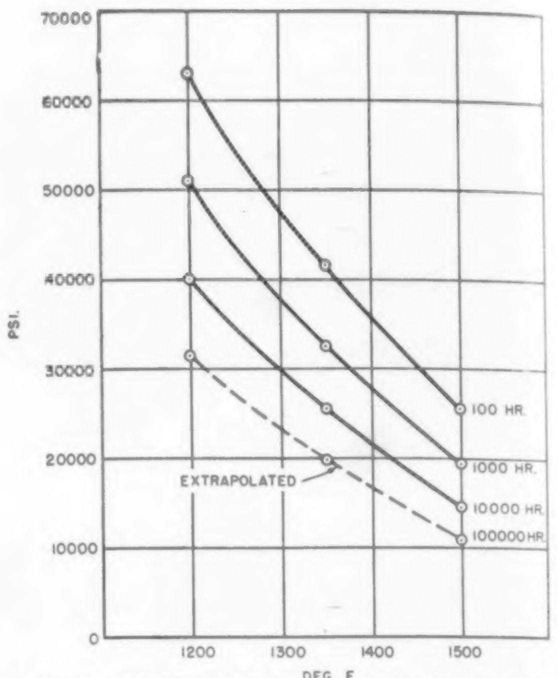


Fig. 2—Stress rupture curves of heat treated alloy S-816.

which are less complex and expensive have been designated as S-590 and S-588. The high temperature strength of all of these alloys is considerably greater than those of the well known hot workable austenitic types of corrosion and heat resisting steels. As very little published information exists on alloys of this type, it seems desirable to discuss the properties and characteristics of S-816, one of the members of this series.

Chemical Composition

It was found that with chromium and nickel properly balanced, the simultaneous presence of molybdenum, tungsten and columbium in correct percentages gave superior strength at 1200 F. Additions of cobalt, long known to provide "hot hardness" or "red hardness," as the textbooks state, gave a perceptible increase in properties at 1200 F. Grades containing 14.00% chromium were soon found to have inadequate oxidation resistance. While chromium additions to about 18.00% could be made without appreciable change in properties, still greater amounts of chromium benefited oxidation resistance at the expense of elevated temperature strength. Cobalt then re-entered the picture, providing high heat strength in a 20.00% chromium composition that excelled the lower chromium alloys with or without cobalt at any temperature in the 1200 to 1500 F range. What had originated as a ferrous alloy gained in total alloy content to become a cobalt base alloy containing iron as an impurity held commercially to a 4.00% maximum.

Nominal Analysis, S-816

Carbon	0.40	Cobalt	44.00
Manganese	1.50 max.	Molybdenum	4.00
Silicon	1.00 max.	Tungsten	4.00
Chromium	20.00	Columbium	4.00
Nickel	20.00	Iron	4.00 max.

Of the elements not previously mentioned, carbon is of major importance. Enough must be present to form strengthening intermetallic compounds and a strong solid solution, but yet not so much that its affinity for chromium causes a phase which melts at the solution treating temperature. For example, the 14.00% chromium alloy with 0.45% carbon will carburize so readily in carbon-rich atmospheres that at 2200 F carbon can be increased by carburization to 3.75% and the steel melted at that temperature. There is also an optimum carbon-columbium ratio of 1:8 to 12, which was determined by creep and rupture tests.

Although manganese in excess of about 1.50% benefits hot working, in company with high cobalt it decreases the elevated temperature strength. Silicon contributes to oxidation resistance; higher percentages of it have been employed deliberately in other Allegheny Ludlum heat resisting alloys, but when above 1.00% it lowers the high temperature strength of S-816.

Not a great deal is known about the specific character of the phases present in S-816. It can be assumed that the chromium, nickel and cobalt form a solid solution along with some part of the other elements. No attempt has been made to ascertain the chemical nature of the ever-present compounds. Judging from hardness responses to various solution and aging treatments, there are at least two sorts of compounds. As all but the nickel and cobalt among the metallic constituents are carbide formers, it is safe to assume the presence of complex carbides. On the other hand, the possible presence of tungstides, molybdides, and/or columbides is conceded. Be the phases what they may, S-816 exhibits behavior in heat treatment quite like other precipitation hardening alloy combinations, although the tempera-

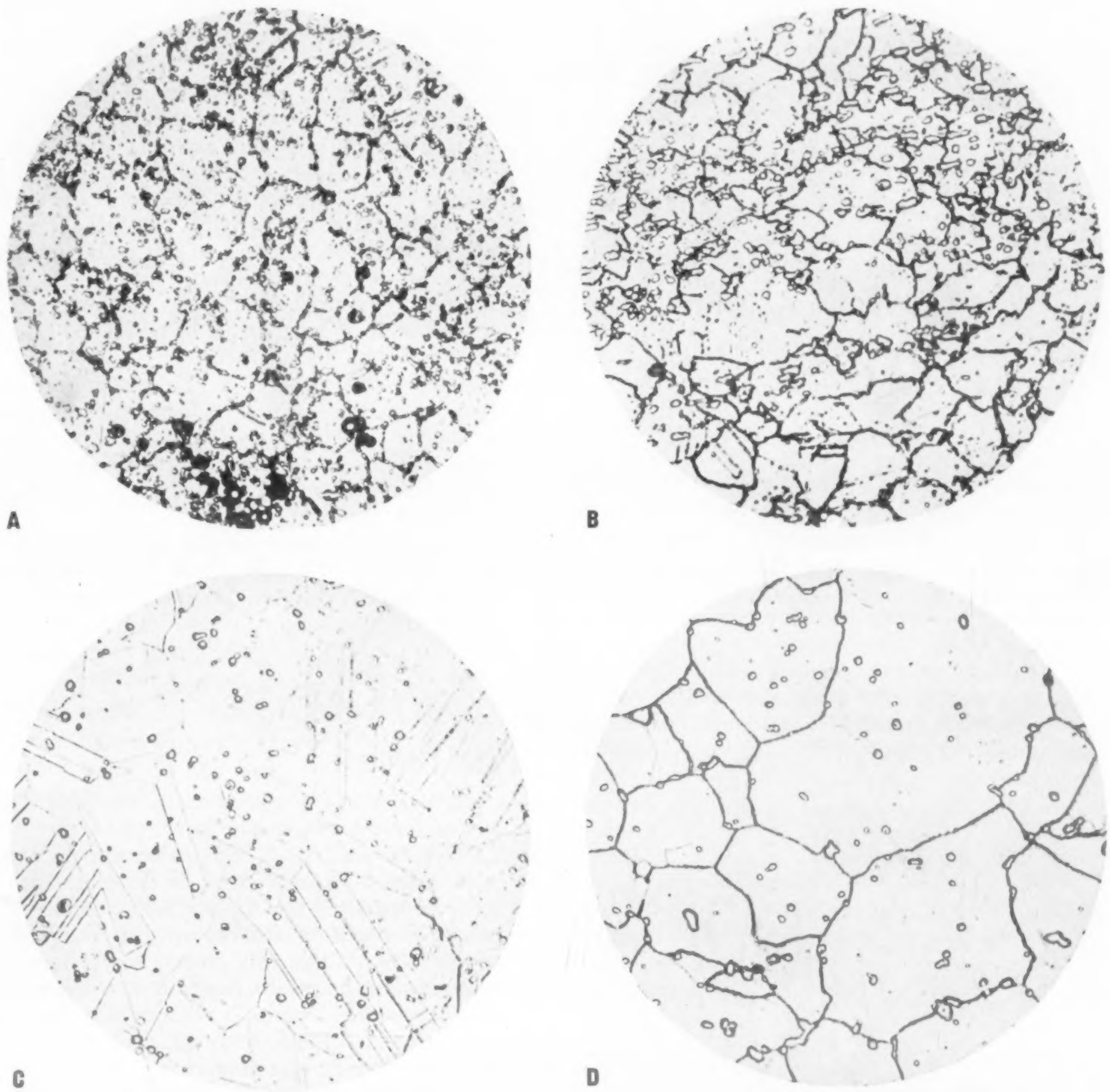


Fig. 3—Cross sections of S-816 at 500X magnification. (A), as forged; (B), as rolled; (C), aged at 2300 F for 1 hr., water quenched; and, (D), aged at 2300 F, for 1 hr., water quenched, plus 16 hr. at 1400 F and air cooled.

ture to effect solution is 2150 to 2300 F and aging is accomplished at 1350 to 1500 F.

Method of Testing

For relatively rapid evaluation of elevated temperature properties, the so-called stress-rupture or time-to-rupture test is valuable. It is intermediate between a short time tensile test (which gives no measure of creep characteristics) and a long-time creep test. The specimen, of modified threaded tensile variety, is suspended in a furnace and dead-weight loaded through a lever system. The furnace temperature is automatically maintained within a ± 5 F tolerance. Strain measurements are made periodically. The more heavily loaded and thus shorter time tests are read more frequently. Different laboratories employ various strain measuring devices, but for comparative testing a high degree of precision is not required.

The value usually taken to represent alloy strength, as the word "strength" is used in the preceding paragraphs, is the stress required to cause rupture in some arbitrary time at the temperature of test. The temperature of test, of course, is included in any statement of rupture strength. For example, two alloys equally strong at 1200 F may not be nearly equal at 1300 F or some other temperature. To arrive at "rupture strength," tests at not less than three different stresses must be made. The times to rupture, plotted against stress on log-log coordinates, should fall in a straight line for any alloy with good structural stability. From this plot stress-to-rupture for

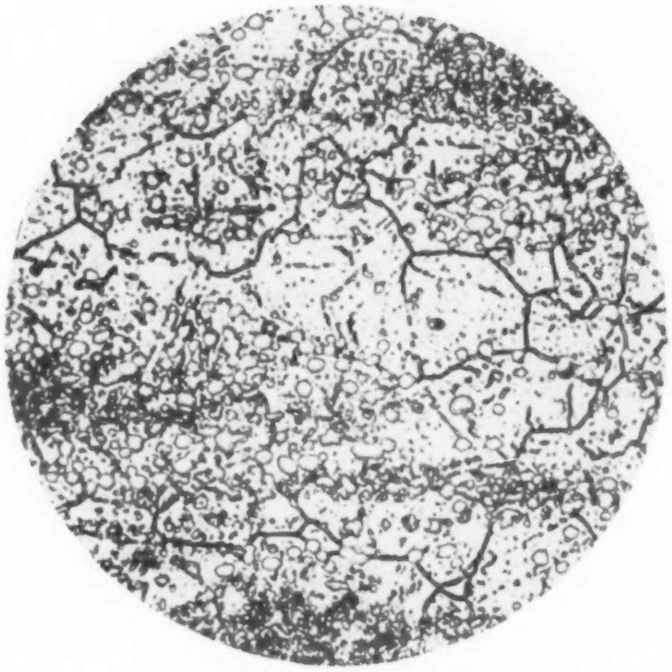


Fig. 4—After more than 6,000 hr. under stress at 1350 F, samples show some agglomeration and chaining of compounds.

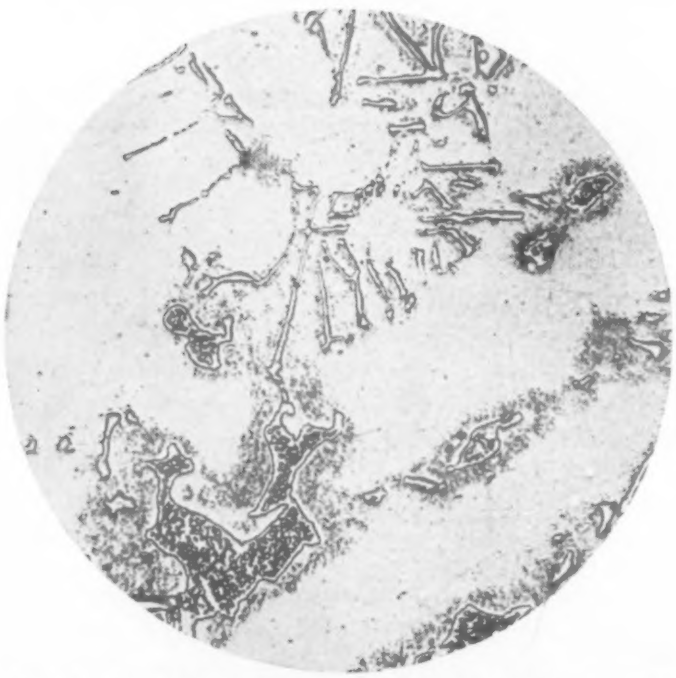


Fig. 5—Microstructure at 500X of a cast rupture sample after 3,719 hr. at 1500 F, 20,000 psi.

times of 10, 100, 1000, 10,000 or 100,000 hr. is extrapolated.

Definite testing schedules are gaited to give information commensurate with intended applications and their expected life. For example, a jet propulsion engine on a fighter plane would require materials to endure extreme service for the combat life expectancy of the airplane — perhaps 100 hr. Then testing would be at high stresses and relatively high temperatures. If, on the other hand, the application were a stationary gas turbine for electric generator drive, testing must be of a nature to reveal the possibilities of 100,000-hr. life (about 11½ years). As testing times approach 10,000 hr., creep (in contradistinction to ordinary plastic deformation) becomes increasingly important, and considerable refinement in strain measurement is necessary. Stress vs. log-time plots are made to show percentage elongations, as illustrated in Fig. 1.

It is also customary to plot the "transition point," that is, the point on the strain-time curve where the second stage creep rate begins to change to accelerated creep leading to rupture. The importance of these data to the design engineer is obvious. Fig. 2 presents a summary of rupture strength in a plot of stress vs. temperature for various rupture times.

Heat Treatment

Some few of the commercially available alloys for elevated temperature service depend on 10.00 to 20.00% of cold work for realization of maximum properties. Such cold work is done usually not at room temperature but slightly below the service temperature, which is still below the recrystallization temperature. While this process serves to accelerate precipitation, its major function is to raise the low temperature yield strength without affecting the ultimate strength. S-816, however, does not depend on this operation to best condition it for service. It is distinctly a heat treatable engineering material. Heat treatment of large turbine bucket wheel forgings is easily done. Stress data are given in Table I.

The employment of S-816 in the as-hot-worked condition will give erratic results, for the properties vary according to the rolling or forging temperature and the amount of reduction at that temperature. The alloy is definitely recommended for use only in a properly heat treated condition.

Table I

Stress to Rupture in Time Indicated			
Hours	1200 F	1350 F	1500 F
100	63,000	41,500	25,500
1,000	51,000	32,500	19,400
10,000	40,000	25,500	14,500
*100,000	31,500	19,700	10,900

* Extrapolated

Table II

Water Quenched From 1 Hour at: (F)	Rockwell C*
2150	31
2200	30
2250	29
2300	29
2350	28

* These values are about 2 to 4 points above minimum.

Heating to the solution temperature can be done in standard equipment in the absence of carbonizing atmospheres. If the demand is for scale-free heat treatment, atmospheres of hydrogen, nitrogen or mixtures of the two are indicated. Otherwise, still air in limited amount will do. Although experimentally conducted salt bath treating shows promise, work is not far enough along to justify recommendations.

Time at heat for solution treating is governed principally by the mass of the work. For thin sections, such as small turbine buckets, sheet, and strip ½ hr. is ample. The larger turbine blades may require one hr., as their root sections are usually greater than ½ in. in least dimension. The large bucket wheels, 3 or 4-in. thick, are usually held about 3 hr. before water quenching. Air quenching does not develop such good properties as water quenching. On smaller pieces this is due in some measure to the quenching stresses which serve to accelerate precipitation during aging.

Conditions of the intended service govern the selection of an optimum solution temperature. Higher temperatures, up to the fusion point of the intergranular phase (perhaps an eutectic) definitely enhance rupture life. On the other hand, ductility may drop to about 1% elongation as a result of extreme solution temperature. Ductility is increased with reduced solution temperature while rupture time is decreased except at low stresses.

It has been found that very low strains (under ½%) made either hot, warm, or cold may make the alloy susceptible to grain growth during the subsequent solution treatment, if the solution temperature is in excess of about 2100 F. However, when final reductions in hot working are adequate, no such difficulty arises. Although large grain is reputed to be conducive to low creep rate, mixed grain may not be favorable to high endurance limit, and many applications involve alternate stresses of high frequency. Grain refinement can be accomplished only by adequate hot work.

Solution is never complete. There is always an abundance of undissolved compounds right up to the point of intergranular fusion. The lower temperatures accomplish less solution, less precipitation on aging, and consequently result in lower strength and higher ductility in the aged condition. Table II shows the as-solution treated hardness declines with increase in temperature, indicating that complete annealing is not attained.

The aging treatments shown in Table III serve to show that the range in temperature is wide if considering hardness alone.

However, rupture strength is quite sensitive to precipitation temperature; the best range is 1350-1500

Table III, Heat 50757

Solution Treated 2300 F Aged 16 Hr. at: (F)	Rockwell C
1000	25-26
1200	25-26
1300	25-26
1400	24-25
1500	24-25
1600	25-26
1700	26
1800	26
1900	23

Table IV, S-816 Bar Stock

Stress-Rupture at 1200 F, 70,000 psi.						
Heat 50757, 2300 F 2 hr., Water						
	Brinell	Rockwell C	Hours	% Elong.	% Red.	Brinell After Test
Aged 1400 F for 2 hr.	255	24				
4 hr.	248	25-26				
6 hr.	255	25-26				
16 hr.	269	26-27				
Heat 41581, 2300 F 1 hr., Water						
	Brinell	Rockwell C	Hours	% Elong.	% Red.	Brinell After Test
Aged 1400 F for 2 hr.	248	26	24	5.0	7.0	229
4 hr.	293	32-33	81	4.0	4.0	262
6 hr.	302	33-34	80	2.0	5.0	311
16 hr.	311	34	82	2.0	1.0	302
Heat 41584, 2300 F 1 hr., Water						
	Brinell	Rockwell C	Hours	% Elong.	% Red.	Brinell After Test
Aged 1400 F for 2 hr.	241	23	26	8.0	4.5	235
4 hr.	293	32	51	5.5	3.5	255
6 hr.	302	33	24	6.5	5.5	241
16 hr.	321	33-34	80	3.0	2.5	302

Table V, Effect of Quench on As-Aged Rockwell C Hardness

One Inch Round Samples Held One Hour at 2300 F and Quenched in Water			
	Not Aged	Aged 6 hr., 1400 F	Aged 22 hr., 1400 F
Quenched Immediately, 1/16 in. Thick	16-18	27-29	32
Quenched Immediately, 1/4 in. Thick	24	31	33
Quenched Immediately, 1/2 in. Thick	27-30	33-34	35
Quenched Immediately, 1 in. Thick	27	29-31	35
Quench Delayed 5 Sec., 1 in. Thick	27-28	32	33-34
Quench Delayed 10 Sec., 1 in. Thick	27	30-31	33-34
Quench Delayed 20 Sec., 1 in. Thick	27	30-31	32-34

F. Experience has shown that a hardness of 26 Rockwell C or higher after solution treating at 2300 F and aging at 1400 F is indicative of good rupture properties, although good tests have been obtained on heats of 22 Rockwell C hardness. Hardnesses in excess of about 34 Rockwell C indicate cold work after solution treating and before aging. After cold work reduction of 20% or so precipitation is vigorous enough to raise the hardness to as much as 44 Rockwell C.

The time for adequate aging varies with chemistry and previous processing history. Most samples that have had a proper solution treatment and quench will age at 1400 F within 6 hr., as shown by Tables IV and V.

Normal aging produces no particular change in the microstructure as seen in Fig. 3, C and D, but it does greatly accelerate the etching rate. Creep test samples that have had more than 6,000 hr. under stress at 1350 F show some agglomeration and chaining of compounds, as indicated by Fig. 4. It is not known, however, what periods of time, temperature, and magnitude of stress are necessary to make agglomeration visible.

The least tensile strength at 1500 F out of a large number of commercially prepared samples was about 70,000 psi.

Fabrication

S-816 has been fabricated by all usual processes, although, because of its greater initial strength and higher work hardening rate, ease of fabrication does not generally equal that of the chromium-nickel austenitic stainless steels. The relatively high carbon content, compared to the ordinary stainless steels, makes some changes and greater care in welding necessary; nevertheless, arc welding and atomic hydrogen welding are regularly done under production conditions.

S-816 is best machined in the fully aged condition. It can be machined at 10 to 15 surface-feet per min. with high-speed tools and approximately 30 to 45 surface-feet per min. with carbide tools. In the as-solution treated condition, the alloy is most susceptible to work hardening.

Commercial production has been limited to billets and bars. Sheet, strip, wire and welded tubing have been produced successfully in experimental quantities.

Table VI

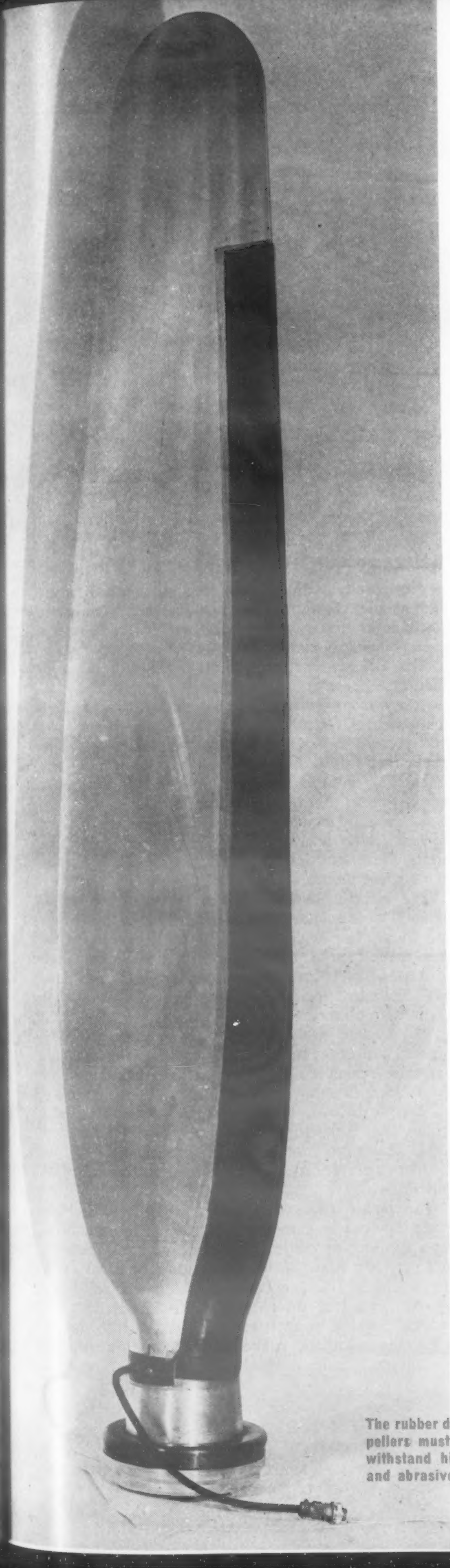
Test Temp. F	100 hr.	1000 hr.
1200	57,000	46,000
1350	39,000	29,000
1500	26,000	20,000
1600	17,500	12,500
1700	13,000	10,000
1800	10,500	8,300

As a precision casting material, S-816 ranks among the superior alloys for high temperature service. Best results have been obtained when pouring temperature and mold temperature together are held within rather narrow limits, as these determine cooling rate and consequently dendrite-compound-eutectic size and distribution. Fig. 5 shows the microstructure at 500 X of a cast rupture sample after 3719 hr. at 1500 F, 20,000 psi. There seems to be some difference of opinion among various laboratories on the value of heat treating cast S-816. However, behavior has been good enough in the as-cast condition that heat treatment is generally considered unnecessary.

Rupture loads for cast S-816 at 1600 to 1800 F are included in Table VI as castings will probably find maximum utilization at temperatures higher than appears to be practicable for wrought materials.

Applications

While the military is continuing gas turbine and jet propulsion developments, the future peacetime applications for S-816 and similar elevated temperature, high strength alloys perhaps will be in ship, locomotive, and central station gas turbine drives. Efficiency of gas turbines being dependent on temperature of operation, the need for alloys of high temperature strength will continue to be of paramount importance. With presently available materials a favorable temperature-stress ratio can be maintained by design control. Under some circumstances, in multiple stage turbines, alloys of strength less than that of S-816 can be employed, for example, Allegheny Metal S-590 (S-816 with but 20% cobalt) and S-588 (cobalt-free).



The rubber de-icers for propellers must be bonded to withstand high centrifugal and abrasive forces.

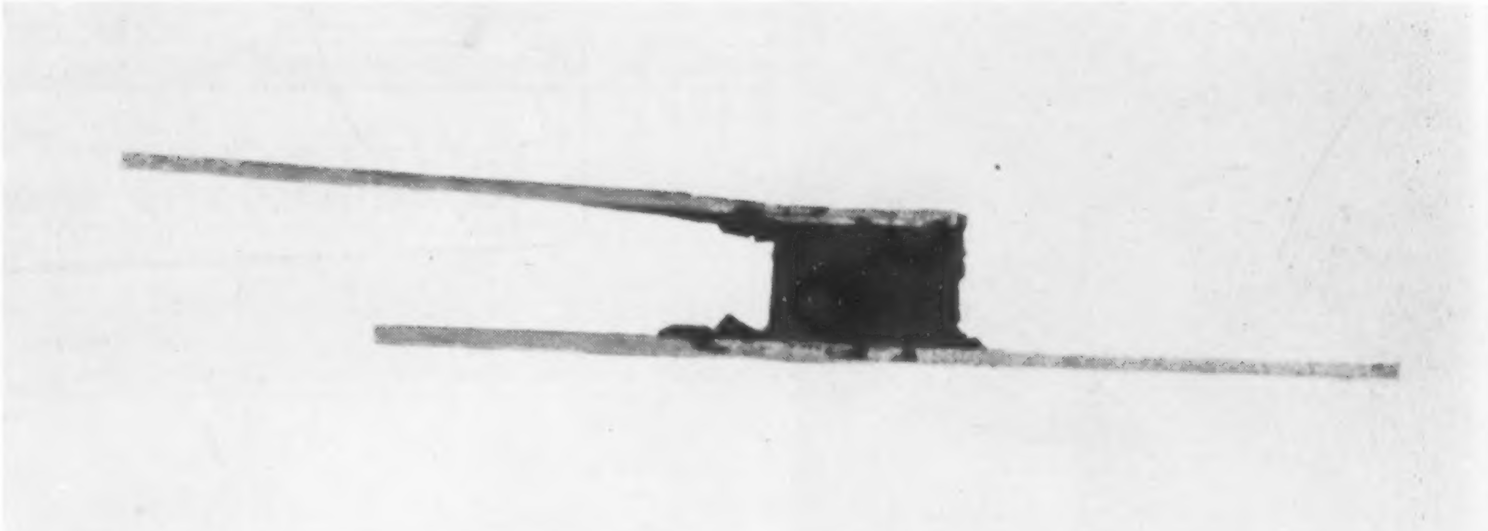
Many interesting engineering possibilities arise from the development of new methods of bonding rubber compounds to most metallic surfaces.

Rubber-Metal Composites

by JAMES A. MERRILL,

Asst. Director of Research, Goodyear Tire & Rubber Co.

DURING THE LAST FIVE YEARS the useful applications of rubber-metal combinations in the engineering field have enjoyed considerable impetus due to the large number of different synthetic rubbers or elastomers which have become available in large quantities. In addition to natural rubber and Neoprene the following rubber-like materials have greatly



Buna N is joined to aluminum in this small helicopter mounting.

stimulated new applications and engineering concepts:

Buna N	Vinylidene Chloride
Butyl Rubber	Vinyl Co-polymers
Silicone Rubbers	GR-S
Vinyl Chloride	Polyethylene
Thiokol Liquid Polymers	

When considering rubber-metal applications probably the first consideration of the designer should be directed toward the type or characteristics of the rubber or rubber-like materials which are at his disposal. Prior to the war the qualities of natural rubber and Neoprene were well known and widely exploited in this field and need not be discussed in detail. A brief review of the distinctive properties of the newer materials is necessary in order to determine the greater possibilities now open.

The *Buna N's* are characterized chiefly by their oil and solvent resistance which is generally much more effective than that of the Neoprene compounds. Excellent resistance to petroleum products are obtainable as well as vegetable and animal fats and oils. Solvent mixtures containing as much as 40 to 50% aromatics can be satisfactorily handled with no more than 15 to 20% volume swell. Contact with acetone, ketones and chlorinated solvents are generally detrimental. Sunlight and ozone resistance are poor compared to Neoprene, but blends with certain vinyl compounds will greatly improve this deficiency.

GR-S replaced most natural rubber with sasisfactory results, having about the same acid and alkali resistance and equally poor solvent and oil resistance. The continued use of GR-S will depend on the availability of crude and the relative price of each.

Butyl rubber usage has been restricted primarily to inner tubes with no major rubber-metal applications. However, its properties are such that applications will undoubtedly develop. Because of its high degree of unsaturation, Butyl vulcanizates are unusually resistant to natural or artificial aging, even in the presence of materials which actively catalyze the deterioration of natural rubber or GR-S. It is highly resistant to most acids, alkalies and ozone and, although swollen by petroleum hydrocarbons, it is resistant to many animal and vegetable oils. For instance, it is more resistant to linseed oil than either Neoprene or the average Buna N compound.

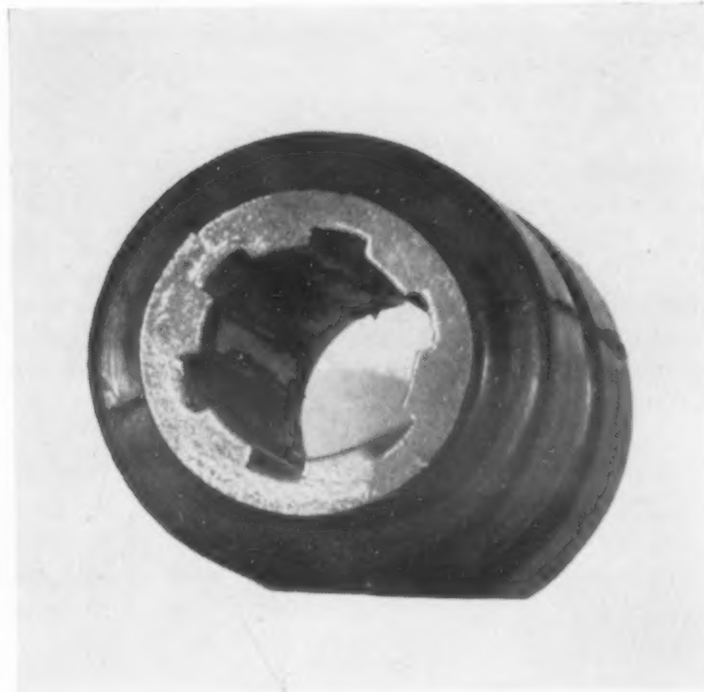
The *Silicone* rubbers are the newest of the synthetics in the elastomer category and are chiefly interesting from their remarkable ability to resist high temperatures. Excellent aging at temperatures from 400 to 500 F have been recorded and it is anticipated that this property will permit many new and interesting rubber-to-metal applications heretofore impossible in the high temperature field. These rubbers have only moderate resistance to oils and solvents with relatively poor tensile and elongation properties, although constant improvement is being accomplished along these lines.

The *Vinyl* materials are generally satisfactory in contact with acids and alkalies, have fair resistance to sunlight, and resist oxidation to a greater degree than natural rubber or GR-S. They can be formulated to stand up well against petroleum products, oils, etc., but are limited for numerous applications because of their thermoplasticity.

Polyethylene has not been utilized in metal combinations directly, but has many properties to warrant extensive research along these lines. It is superior to the rubbers in aging characteristics and resists almost all chemicals with the exception of hot aromatics. It has been successfully used to carry concentrated nitric acid when fabricated into a removable cell or bladder to prevent corrosive action of the acid in metal containers.

The *liquid Thiokol polymers* are interesting because they can be converted to a rubber-like material by a dipping or casting technique without pressure and very low heat. Shrinkage is not a problem since the liquid is 100% converted with no solvents required. Excellent solvent resistance is obtained although physical properties are poor in comparison with other synthetic rubbers. Applied internally by the fill and drain method to riveted or otherwise

Here rubber is bonded to a carbon washer.



For a washing machine, this die cast zinc spline required a rubber coating.

fabricated tanks, a good leak-proof and corrosion resistant coating can be obtained.

What Metal with Which Compound?

The second and equally important consideration of the designer must be directed toward the types of metals, alloys or other rigid materials that can be successfully combined with the desired rubber or rubber-like compounds. Fortunately, increasing adaptation of light metals, powdered metals, plastics, etc., to new and improved products has given the rubber industry an opportunity to thoroughly explore the possibilities of bonding various types of rubber compounds to these materials with highly satisfactory results.

The earliest methods of bonding rubber to metal were limited to attachment by mechanical means of one kind or another. In 1853 Charles Goodyear disclosed bonding to metal through the medium of a hard rubber interface. This method was used for many years, the best example being the attachment of solid rubber tires to rims for automotive and industrial tire applications. Prior to the war, production methods of obtaining adhesion for most molded goods items such as motor mounts, vibration dampeners, wringer rolls, etc., centered largely around brass plated adhesion surfaces, with the result that rubber vulcanization was confined chiefly to brass plated steel, cast iron, brass, etc.

Lack of industrial demands for a production method requiring adhesion to other than brass plated surfaces for molded goods confined the industry's work in this field to the laboratory. Here several different types of adhesion methods were successfully developed for bonding natural rubber and Neoprene to the lighter metals and plastics long before they came into wide industrial and manufacturing use. However, wartime changes in type of products, material substitutions, aircraft demands and large volume requirements brought into production the laboratory methods of obtaining adhesion to these materials that could not be readily or economically brass plated. These wartime developments, along with prewar experience, have made it perfectly feasible and economical to get excellent adhesions of the various rubbers to aluminum, carbon, die castings, powdered metals, plastics and many other materials.

Outside of the molded goods field, parallel developments have been successfully translated into economical means of production for the corrosion protection of storage tanks, mixing equipment, pipe lines, reaction vessels, filter plates, pumps, exhaust fans, and similar equipment. Although the large majority of prewar units of these types used natural rubber, GR-S was successfully substituted during the war, and methods satisfactorily developed and proven for Buna N and certain vinyl compounds where their specific characteristics were required. Here also, almost all of the structural materials encountered in present day fabrication can be used as a base to adhere the various rubbers or rubber-like materials now available.

A knowledge of the methods of metal preparation, adhesive application, rubber preparation and vulcanization is also an important consideration. In general, it can be stated that the base material must be absolutely clean and free from all dirt, grease, oxides, scale and rust. Best adhesive results are obtained by proper roughening of the surface either by sand blast or appropriate pickling solution. The adhesive is then applied either by brush or spray and a drying time dependent upon the solvents present is required before covering with rubber. Some adhesives necessitate a moderate baking time to prevent flow from the

interface when heat and pressure are applied for a molding operation. Vulcanization temperatures in a molding operation usually reach 300 F or more to effect curing in a minimum of time—thermoplastic compositions are not economically bonded to metal in a mold because of a prolonged time cycle caused by the necessity of cooling before release of pressure. With larger items such as tanks, storage vessels, etc., the rubber is calendered to the required thickness, applied over the adhesive by hand application and rolling, and vulcanized either with steam in an autoclave or under hot water. Various modifications of these methods are, of course, possible such as hot air vulcanization, application of heat and pressure by one of several so-called airbag techniques, or, in the case of pre-vulcanized or thermoplastic materials, cementing both surfaces to be bonded, drying, reactivating the surfaces to be adhered with solvent and then joining the surfaces without heat.

From the standpoint of the rubber technologist interested in rubber-metal combinations the greatest problem was the development of adhesives suitable for bonding the various elastomers to the different metals or plastics so that good bonds could be obtained under wide temperature conditions, solvent effects, etc. That this has been done is evidenced by the fact that a rubber-metal bond is no longer considered worthy of the name unless integral adhesions are obtained under the desired operating conditions. Unfortunately, no single adhesive or procedure has been developed that is suitable for all elastomers, or even for any single elastomer to all the various types of materials to which a requirement for bonding might be desired. Suitable techniques are, however, available for almost any imaginative combination of materials that are produced in larger than pilot plant operations.

Examples of Composites

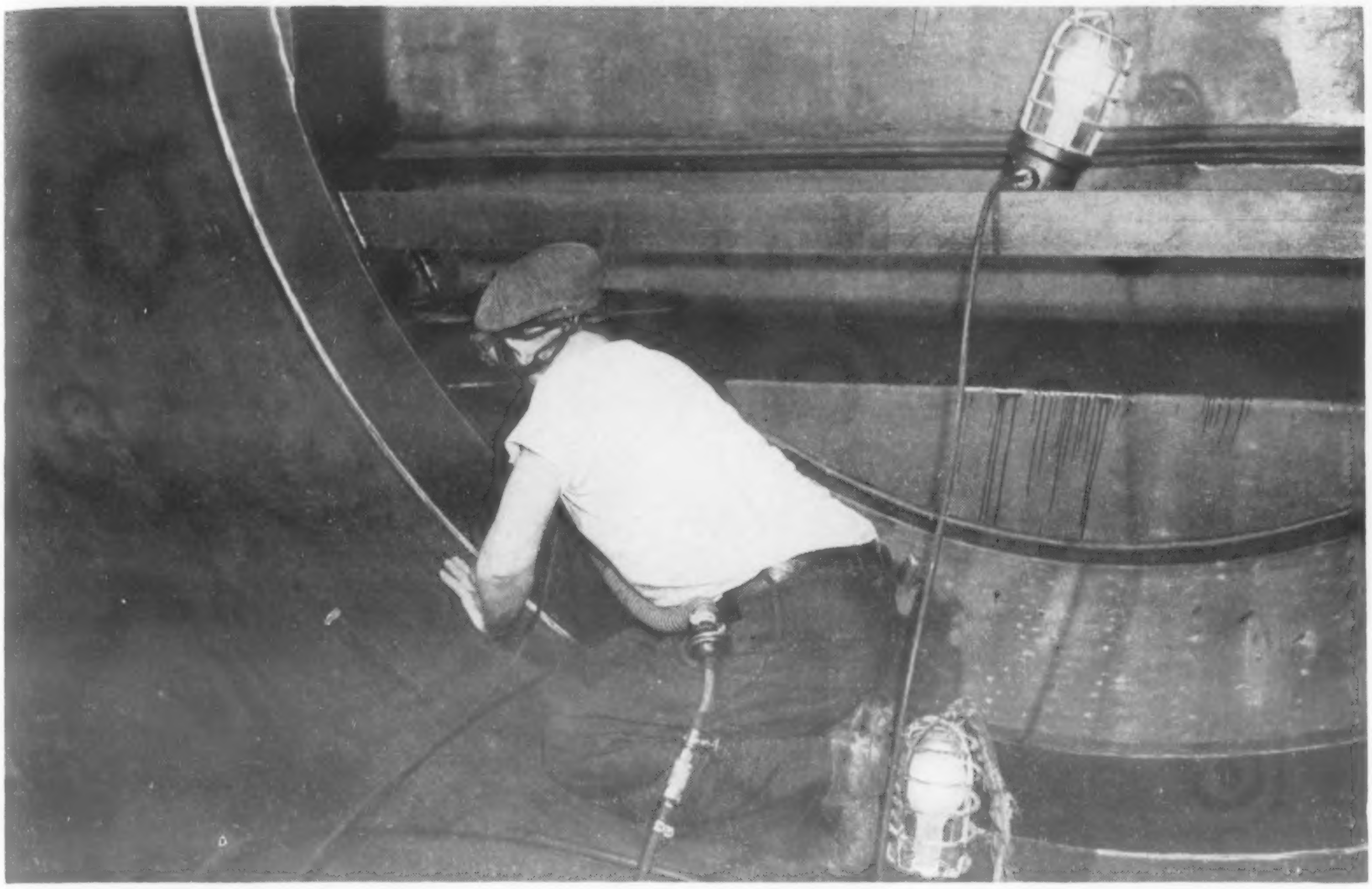
Typical example of adhering Buna N to aluminum is a small mounting for a helicopter. The adhesion is obtained by thoroughly cleaning the metal by sand blasting, then coating the adhesion surface with a thin coat of a phenolic type resin cement to which the rubber is vulcanized.

Necessity for bonding rubber to carbon washers has developed on many occasions and is accomplished by cleansing the carbon through degreasing and then coating with a chlorinated rubber type cement to which a Neoprene compound is then simultaneously vulcanized and bonded.

Natural and Synthetic Rubbers and Rubber-Like Materials

	Natural Rubber	Neoprene	Buna N	GR-S	Vinyls	Butyl Rubber	Silicone Rubbers	Polyethylene	Liquid Thiokols
Tensile Strength, psi.	1,200-5,000	1,000-2,500	1,000-3,500	1,000-2,500	2,000-5,000	1,500-3,000	400-700	1,300-3,000	300-800
Elongation—%	300-800	300-800	300-700	300-600	150-500	600-900	75-300	100-300	300-500
Effect of Sunlight	Poor	Fair	Poor	Poor	Slight	Slight	Slight	Slight	Slight
Effect of Weak Acids	O.K.	O.K.	Fair	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
Effect of Strong Acids	Fair[1]	Fair	Fair[1]	Fair[1]	O.K.	Fair[1]	Fair	O.K.	Fair[1]
Effect of Weak Alkalis	O.K.	O.K.	Fair	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
Effect of Strong Alkalis	O.K.	O.K.	Fair	O.K.	O.K.	O.K.	O.K.	O.K.	Fair
Oil Resistance	Poor	O.K.	O.K.	Poor	O.K.	Poor	Fair	O.K.	O.K.
Resistance to Aromatics	Poor	Poor	Fair	Poor	Fair	Poor	Poor	O.K. below 50°C	Fair
Chief Uses or Characteristics	Corrosion resistance, abrasion, general purpose	Good ageing, oil resistance	Oil and solvent resistance	Natural rubber substitute	Acid resistance	Good ageing	High temperature	Chemical resistance	Liquid application

(1) except oxidizing acids.



The rubber-lining in such tanks as this are cured by injecting steam into the tank interior.

One of the important parts of vastly improved washing machines is a zinc die cast metal spline used in the washing machine gyrator. Operation of this part requires rubber covering which is provided by sand blasting the outer surfaces of the metal spline and then adhering with a chlorinated rubber type cement. Another use of chlorinated rubber type cement is found in the manufacture of a bushing using a steel outer metal and powdered bronze inner metal. In applications of this type, it is necessary that all of the oil be removed from the bronze insert before the curing operation. The oil can then be replaced.

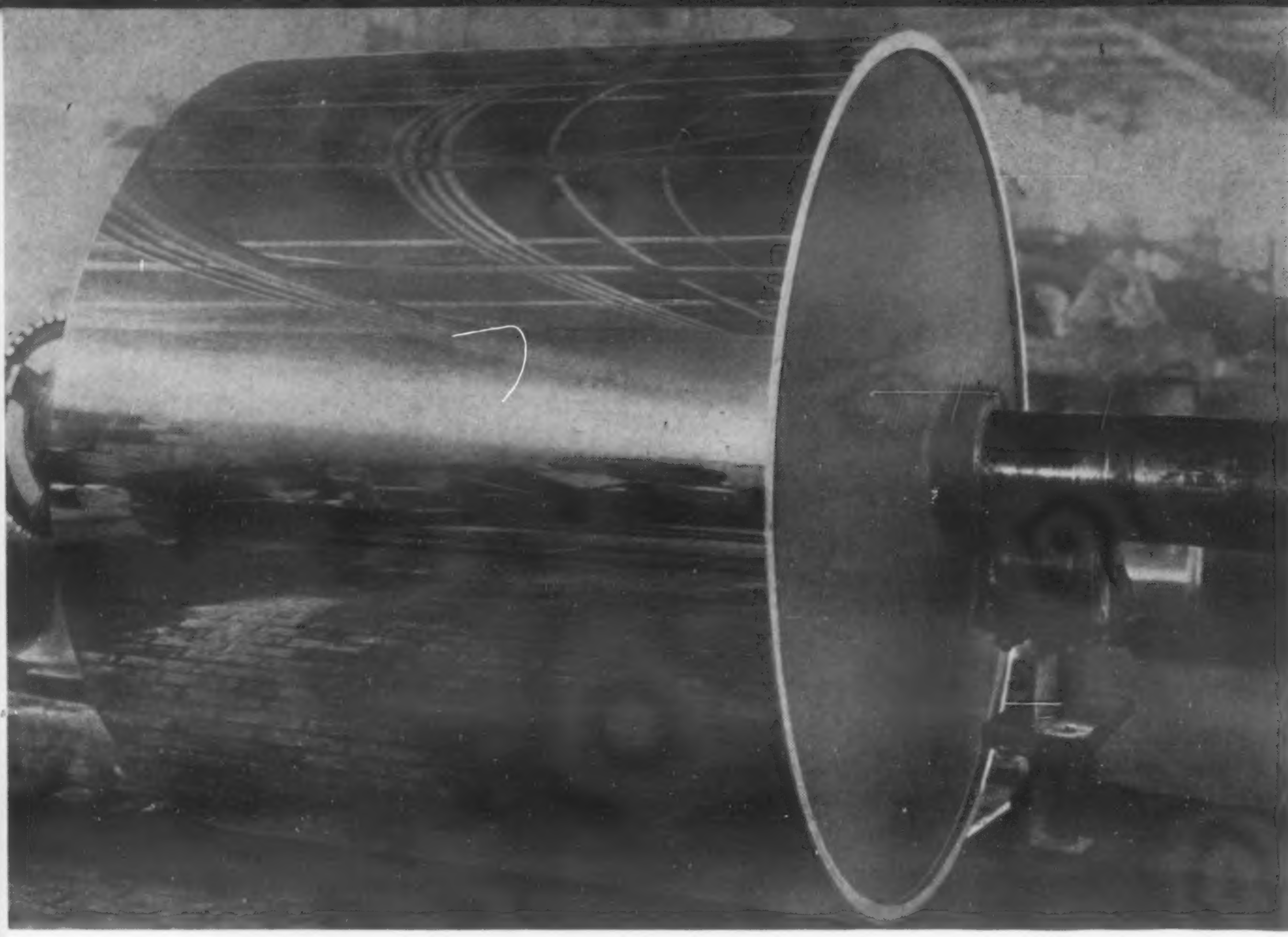
For lining tanks, pipes, covering exhaust fans, etc., special adhesives made by "cyclizing" or "chlorinating" natural rubber or certain synthetic rubbers are used. These adhesives can be considered thermosetting to the extent that they will give integral bonds at the temperatures to which the rubber covering itself can be recommended.

Other typical examples of newly developed techniques are the bonding of Neoprene covered electrically conductive rubber deicers for aircraft propellers. Here the pre-vulcanized rubber unit is attached to the propeller with sufficient strength to hold up under the high centrifugal and abrasive forces that are developed in this service. Pre-vulcanized Buna N has been adhered to Lucite or Plexiglas with Pliobond cement to give peel strengths as high as 25 to 30 lb. per in.

No attempt will be made to outline the bond strengths that can be obtained by the various types of available rubbers since the pounds per sq. in. obtainable in tension or shear or the pounds per in. in a peel test could not be predicted without a complete description of the physical properties of the rubber compound itself. For example, a good adhesion with a tread stock type of natural rubber should approach or exceed 1000 psi. in tension whereas a pure gum adhesion would be considered satisfactory at around 300 psi. In both cases the adhesive forces would exceed the cohesive forces, with failure substantially within the rubber.

In general, it can be stated that all of the common metals are now generally acceptable as materials to which rubber can be adhered. Plated metals, with the exception of the proven brass plated type, are not conducive to good adhesion. It is, however, often possible to plate the metal after the rubber has been bonded. This method proved quite useful during the war in the manufacture of Navy parts on which cadmium plate was required.

These new techniques open large fields to the design engineer for using rubber in conjunction with his product. Rubber to mount machinery and accessories, rubber to isolate vibration, rubber covered rolls, rubber for abrasion and corrosion protection, rubber bearing cushions, bonded rubber bushings, electrically conductive rubber for heat applications and hundreds of other possibilities are daily becoming an actuality.



Welded steel drum 72-in. dia. x 60-in. face; weight approximately 6 tons. Chromium plated and polished at Waterbury plant of Chromium Corp. of America for a manufacturer of coated paper.

Hard Chromium Plate and Its Uses

by J. M. HOSDOWICH, *Chief Chemist, United Chromium, Inc.*

THERE IS A NEW APPRECIATION of old uses for hard chromium plate. By the late twenties and early thirties, all but a few of the present uses had been tested and applied with promising results; but many manufacturers did not fully appreciate the saving of time, labor and materials effected by hard chromium plate until the last few years.

The term "hard chromium plate" has become so well established for distinguishing engineering applications of electrodeposited chromium from decorative applications that we now use it without apologizing for its inexactness. However, the term "thick chromium plate" would be more appropriate. The extremely thin chromium plate used for decorative purposes on consumer products serves as a nontarnishing outer coat for the underlying nickel and copper electrodeposits which prevent the steel basis metal from rusting. This decorative chromium plate is actually just as hard as "hard chromium plate," although it seems soft because it appears to be scratched with a knife.

The research laboratories of United Chromium, Inc., in 1932, prepared specimens of chromium plate deposited under a wide range of conditions and determined the hardness of each by moving it at a definite speed under a specially designed diamond point carrying a definite weight, and then measuring the width of the scratch under the microscope. After testing a large number of specimens, it was concluded that all chromium deposits which come out of the plating solution with a so-called "bright plate" have the same hardness, equivalent to 1000 to 1025 Brinell. It was also found that on extended treatments at temperatures above 550 F, the hardness of electrodeposited chromium decreases and approaches that of cast chromium.

The cross sections in Fig. 1 show the difference between decorative chromium plate and hard chromium plate. In the thin decorative chromium plate, (A), the V-shaped notch is the cross section of a "scratch" made by a knife. The chromium plate itself is not scratched, because it is harder than the steel knife, but it is pressed into the comparatively soft nickel plate lying beneath it, leaving a groove on the surface which looks like a scratch. The "hard chromium plate," (B), is no harder, but is so thick that it is not indented.

When a shop worker or inspector tests a piece of chromium plated steel with a file to see if it is "hard chrome" or "soft chrome," he is really testing the comparative thickness of the chromium plate, as the file appears to cut into a thin plate but slides off a thick plate. Actually, most hard chromium plate is of the "bright-plate" type; that is, the surface of the plate perfectly reproduces the surface of the steel basis metal. As all "bright-plate" has the same hardness,

Hard chromium plate, more properly "thick chromium plate", has a wide variety of uses gained through its numerous valuable characteristics.

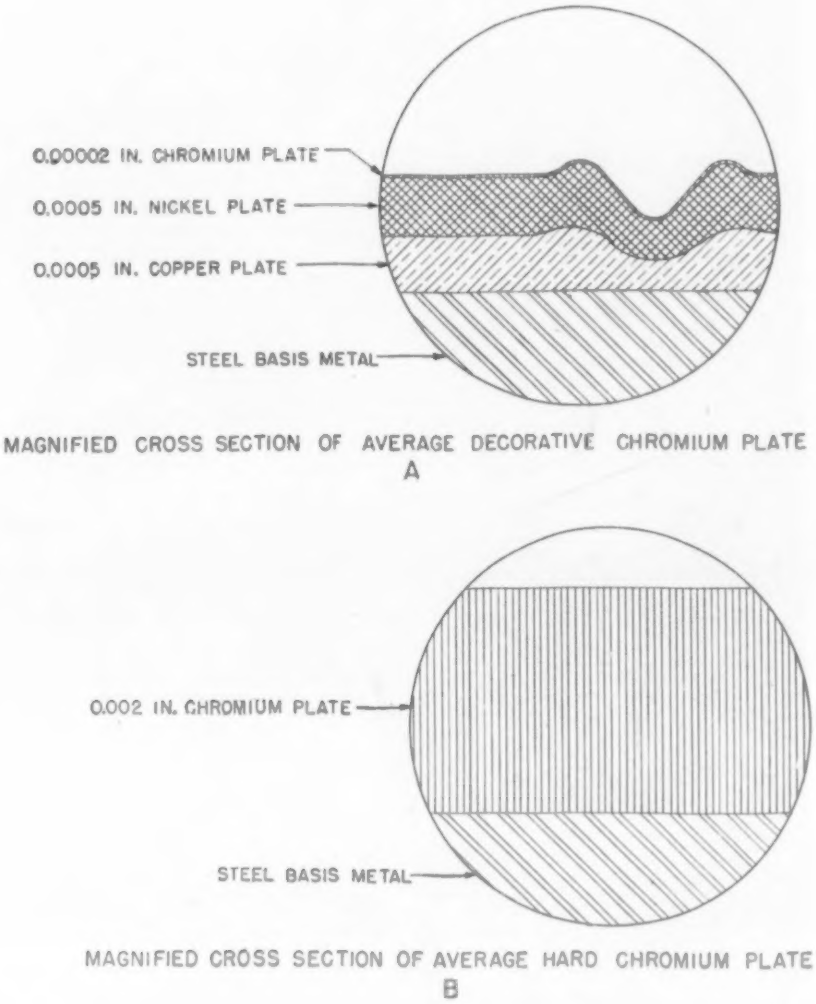


Fig. 1. Magnified cross sections showing the difference between decorative chromium plate and hard chromium plate. The V-shaped notch in A is the cross section of a "scratch" made with a knife.

even when produced under widely varying conditions, there is no need for the user of hard chromium to test the hardness of the chromium plate.

However, he should be sure that the chromium plate is thick enough to withstand the service conditions and that the steel basis metal is hard enough and strong enough to support the chromium plate without distorting under the service load.

The relative hardness of the common metals is shown in Fig. 2. Moh's Scale, being based on the fact that each metal can be scratched by the metal below it, indicates relative hardness but not the degree of hardness— for example, a metal registering 8 on the scale may be several times as hard as a metal registering 7. According to Moh's Scale and also according to other methods of measuring hardness, chromium is the hardest of the common metals. This hardness is largely responsible for the increased wear of chromium plated plug gages, drawing dies, printing rolls and other manufacturing equipment.

Unusual Resistance to Corrosive Chemicals

The hardness of chromium alone would not account for its steadily increasing use as an industrial tool. Its success is due to the unique combination of hardness with other properties such as corrosion resistance and low coefficient of friction. The chemical resistance

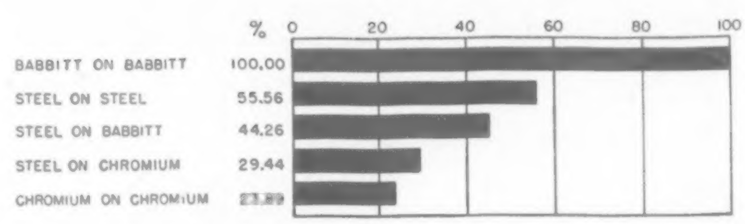


Fig. 2. Comparative hardness of metals (Moh's Scale).

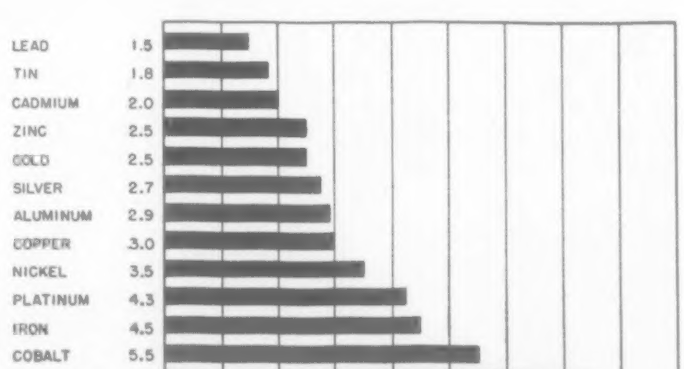
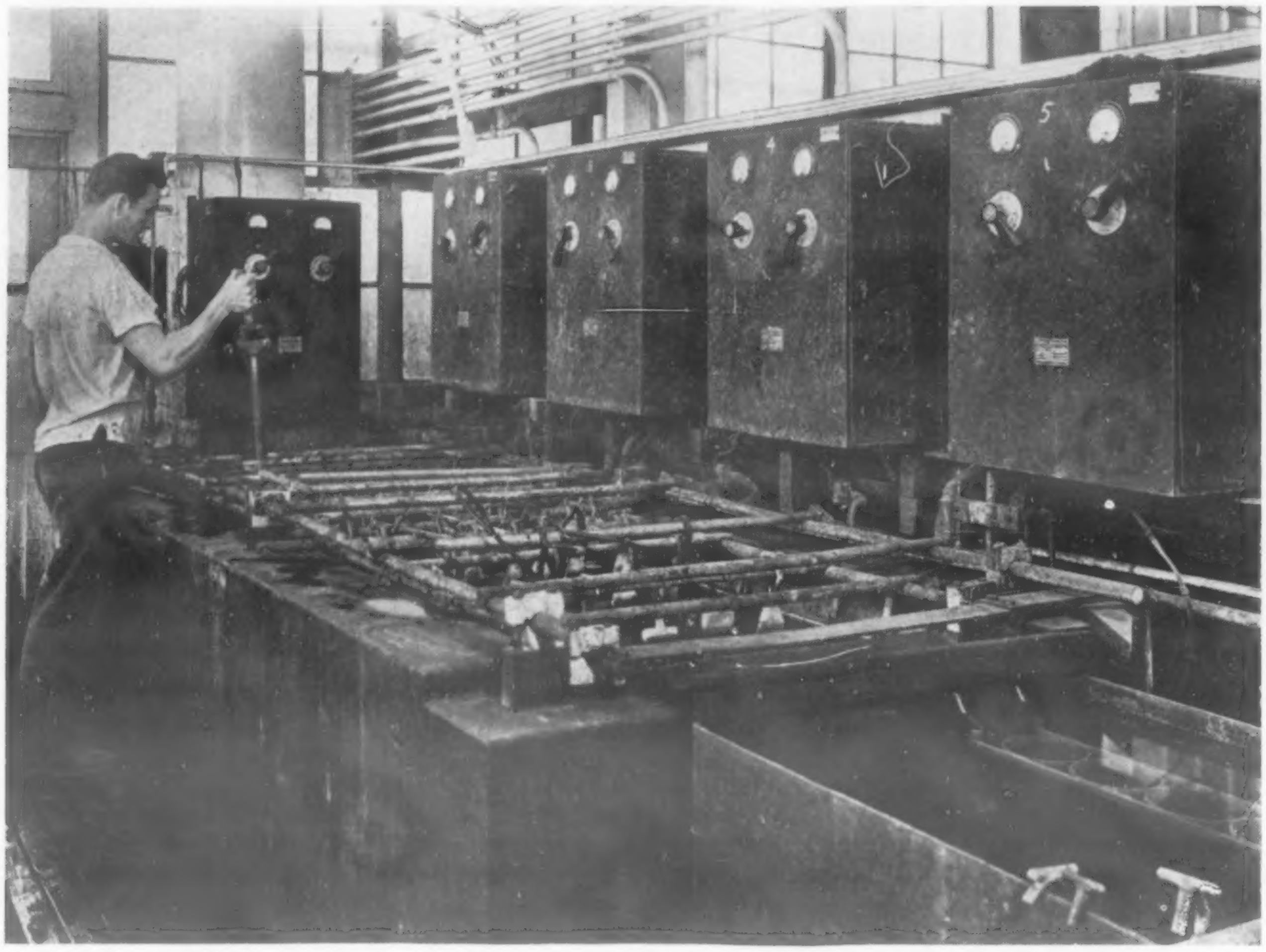


Fig. 3. Comparative static friction of various metal surfaces.



Five-bay tool plating unit at Gilbert Cummins & Co., Baltimore, with separate rectifier for each bay. This design permits close control of current and special positioning of anodes required for hard chromium plating.

of chromium is illustrated in the following list. According to tests made by Chromium Corp. of America, chromium has excellent resistance to 10% solutions of the listed chemicals (except where higher concentrations are noted) at a temperature of about 55 F.

Chromium Has Excellent Resistance to These Chemicals

Acid, Acetic	Calcium chloride
Acid, Benzoic, sat.	Carbon dioxide
Acid, Butyric	Carbon disulfide, sat.
Acid, Citric	Carbon tetrachloride, sat.
Acid, Hydrobromic	Carbon tetrachloride, 100%
Acid, Hydroiodic	Chlorine, dry
Acid, Lactic	Chlorobenzene, sat. and 100%
Acid, Nitric	Chloroform, sat. and 100%
Acid, Nitric 100%	Copper sulfate
Acid, Oleic	Ferric chloride
Acid, Oxalic	Ferrous chloride
Acid, Palmitic 100%	Glue
Acid, Phosphoric c.p.	Hydrogen sulfide, 100%
Acid, Phosphoric c.p. 85%	Magnesium chloride
Acid, Picric, sat.	Petroleum crude
Acid, Salicylic sat.	Phenol
Acid, Stearic 100%	Printing ink
Acid, Tartaric	Sodium carbonate
Aluminum chloride	Sodium chloride
Aluminum sulfate	Sodium hydroxide
Ammonia	Sodium sulfate
Ammonium chloride	Stannous chloride
Atmosphere	Sulfur, 100%
Barium chloride	Sulfur dioxide, 100%
Beer	Sugar
Benzyl chloride, sat.	Zinc chloride
Benzyl chloride, 100%	Zinc sulfate

These corrosion-resisting properties are of great value in any application, but are especially useful in the chemical, paper, and textile industries. As chromium is nontoxic, it makes an ideal coating for food-handling equipment.

Low Coefficient of Friction

Chromium has a slippery surface which not only permits it to slide freely against metals or other materials, but prevents solids and liquids from adhering to it. The graph in Fig. 3 shows the comparative static friction between a number of metals including chromium. The low coefficient of friction makes chromium valuable for plating cutting tools to decrease the friction of the chip against the tools. It also reduces friction and wear between piston rings and cylinders in gasoline engines and between plungers or rams and their packing.

Many Uses for Hard Chromium

It is to be expected that many uses would be found for an electrodeposited metal having such a remarkable combination of properties. The number of uses has steadily increased since Dr. Colin G. Fink invented the process of commercial chromium plating in 1924. A number of new applications developed during the war are still guarded as trade secrets. Hard chromium is used in the manufacture of the machinery and equipment listed below.

Partial List of Machinery and Equipment Hard Chromium Plated

Airplane parts	Meat packing equipment
Automotive equipment	Metalworking machinery
Brewing apparatus	Milling machinery
Canning machinery	Oil refining equipment
Chemical equipment	Packaging machinery
Dairy equipment	Paper mill machinery
Dough molding machines	Petroleum equipment
Electric appliances	Plastic molding machinery
Engine parts	Printing machinery
Extruding equipment	Pulp manufacturing equipment
Food products equipment	Refining apparatus
Glass manufacturing equipment	Rubber machinery
Grinding machinery	Sewing machine parts
Machine parts	Steel mill equipment
Hydraulic machinery	Sugar refining apparatus
Laundry equipment	Textile machinery

In a bulletin published in 1942 by Chromium Corp. of America, a list of 163 industrial applications for hard chromium plate is given. The applications here listed are selected to illustrate the wide variety of parts plated with hard chromium.

Partial List of Applications for Hard Chromium Plate

Arbors	Evaporator tubes	Plungers
Bearings	Filters	Press plates
Broaches	Gages	Printing rolls
Calender rolls	Gears	Punches
Cams	Graining rolls	Rams
Cheese screens	Guides	Reamers
Coal briquet rolls	Hoppers	Schreiner rolls
Coating rolls	Kettles	Scrapers
Condenser tubes	Knives	Screen plates
Crankshafts	Leather press plates	Shafts
Cutters	Mandrels	Spindles
Dies	Mixers	Suction box covers
Doctor blades	Molds	Straightener rolls
Drills	Pans	Taps
Drying drums	Pasteurizer coils	Tensions
Drying plates	Photoengraved rolls	Valves
Embossing rolls	Pistons	Worms

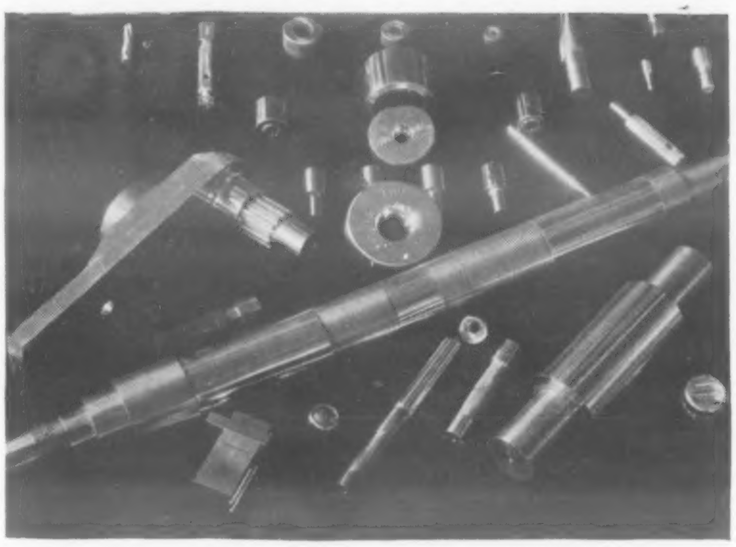
The proved advantage of using hard chromium plate is illustrated by a few definite cases discussed in the following paragraphs, giving actual figures taken from production records.

Gages

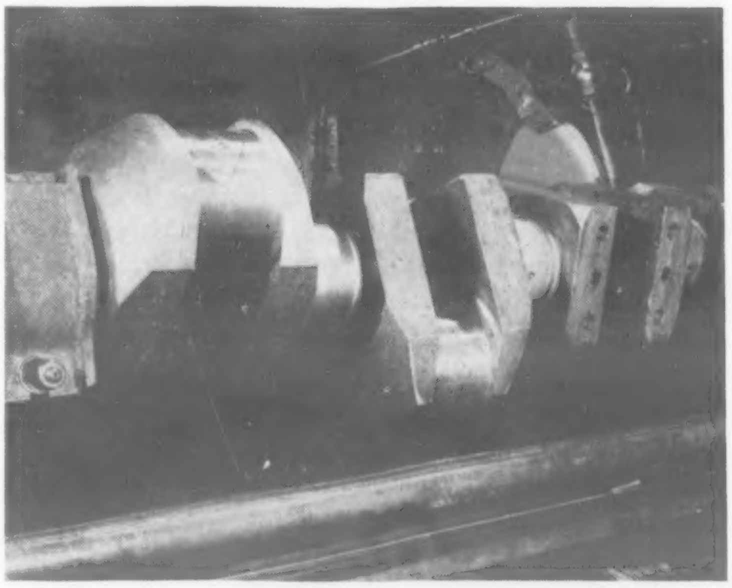
One of the earliest uses for hard chromium plate was on gages. Hardness of the chromium increases resistance to wear, and the nonsticking property practically eliminates picking up or seizing to the work. It is good practice to grind the gage undersize, plate it with chromium oversize, and then grind and lap to size so that the gage can be worn below its tolerance without exposing the steel. This procedure enables the gage to be worn out, stripped and replated many times.

According to numerous reports received over a period of years, chromium plate increases the service life of gages from three to several hundred times. A large automobile manufacturer recently reported that the overall cost of chromium plated plug gages was less than one-sixth that of unplated gages. The following figures are taken from the production records of this company. In one gaging operation, chromium plate increased the number of holes gaged from 1,300 to 18,034 before the gage was worn below the tolerance of 0.0005-in. In another case, un-

Hard chromium plated gages and drills.



Assortment of hard chromium plated parts.



Worn diesel engine crankshaft salvaged by hard chromium plating.

plated gages averaged 2,000 holes in aluminum and bronze while chromium plated gages averaged 20,000 holes. There is one record where a single chromium plated gage outlasted fifty-four unplated gages. In a certain grinding operation, a chromium plated gage stood up 218 hr., whereas 4 hr. was formerly the limit.

Cutting Tools

Cutting tools are chromium plated not so much to take advantage of the hardness of chromium, as to make use of its slippery surface which enables chips to slide off freely, thus helping to prevent overheating with its softening effect on the cutting edge. The property of chromium which prevents other materials from sticking or welding to it at high pressures and elevated temperatures is especially useful in cutting nonmetallic materials such as plastics, hard rubber and slate, and nonferrous metals such as brass and aluminum.

The chromium plating of cutting tools has long been advocated by United Chromium, Inc. and practiced for many years. This application of chromium plate grew slowly until the beginning of the war. The sudden increase in production of machined parts and the shortage of cutting tools focused attention on methods for getting greater production from each tool. As a result, the adoption of chromium plate on cutting tools was greatly accelerated. The increase in production is illustrated by data taken from factory records.

Improved Production of Chromium Plated Cutting Tools

Tool	*Pieces per Grind* Before Plating	After Plating
0.136 in. dia. Reamer	87	335
0.237 in. dia. Reamer	15	75
0.327 in. dia. Reamer	12	70
0.2770 in. dia. Twist Drill	35	80
0.453 in. dia. Twist Drill	30	136
0.165 in. thick T-Slot Cutter	45	250
CT 9234A—Milling Cutter	200	600
CT 9404/1—Milling Cutter	100	200
0.290 in. dia. D Bit	1–2	7–12

Dies

The combination of its hardness, low coefficient of friction and nongalling characteristics accounts for the use of hard chromium on a wide variety of metal drawing and forming dies. Manufacturers have found that hard chromium plate not only increases service life of their dies but improves the finish on their products. Data shows the effect on the service life of chromium plating dies for certain operations:

Service Life of Chromium Plated Dies

Application	*Service Life* Unplated	Plated
Blanking and Drawing Stainless Steel	500 pieces	20,000 pieces
Drawing	4,000 pulls	75,000 pulls
Forging a Tube Thimble	9,000 pieces	23,000 pieces
Forming	300 per hr.	7,000 per hr.
Pressing Stainless Steel	25 pieces	250,000 pieces
Ring for Coining Die	200,000 pieces	600,000 pieces
Shearing Laminations	50,000 pieces	391,250 pieces
Swedging Rivets	3,000 pieces	24,000 pieces
Swedging Wire	4 hr.	52 hr.

Rolls and Drums

A wide variety of rolls and drums used in the paper, textile, printing and other industries are chromium plated. In many cases, the increased service life of the plated over the unplated rolls is not yet known because the plated rolls have not been removed from the machines since they were installed. Other advantages of the plated rolls are that the stock does not adhere to them and they produce a finer finish on the product. The chromium plate improves the printing qualities of engraved printing rolls, and, when the designs show wear, replating restores the original sharpness without re-engraving. The following tables show comparative data on the service life of certain rolls used in the paper and textile industries and for the printing industry.

Service Life of Chromium Plated Rolls in the Paper and Textile Industries

Type of Roll	*Service Life* Unplated	Plated
Calender	2 to 3 weeks	½ to 1 year
Embossing	3,000 reams	18,000 reams
Embossing	57,000 pieces	1,000,000 pieces
Schreiner	6 months	3 to 4 years
Schreiner	200,000 yards	3,855,548 yards
Textile	200,000 yards	1,200,000 yards
Textile	75,000 yards	8,000,000 yards

Service Life of Chromium Plated Printing Rolls

Application	*Service Life* Unplated	Plated
Cards	5,000	25,000
Intaglio	2,500 copies	15,000 copies
Intaglio	300,000 copies	2,000,000 copies
Oilcloth Printing	800 tons	6,800 tons
Photogravure	15,000 copies	120,000 copies
Postage Stamps	50,000	1,000,000
Printing Roll	50,000 pounds	300,000 pounds

Salvage

Hard chromium is the "putting on" tool long in demand by machinists. Properly applied, it forms a perfect bond to the basis metal and its properties are such an improvement over those of the basis metal that the part after salvaging is better than when new. A manufacturer of food products had several worn out steel shafts for centrifugal pumps salvaged by chromium plating. As the pumps were used for handling fluids containing vinegar, the steel shafts required replacement every few months. After chromium plating, the shafts showed no signs of wear after five years. One plant salvaged several hundred cut and draw punches with off center punch bearings by grinding them oversize and then chromium plating. Another plant had just completed an order for 700 spindles when the specifications were changed to a larger diameter. These spindles were built up with hard chromium and delivered without delay.

Metal is poured from the rotatable ladle as the molds move by the first station.

Permanent Mold Gray Iron Castings

by EDWARD C. HOENICKE, *General Manager, Foundry Div., Eaton Manufacturing Co.*

ALTHOUGH MANY OPERATIONS in sand casting are difficult to mechanize, the number of machines available to the foundry is steadily increasing as the ingenuity of the machine designer and the process engineer attack the problem. Today, such machines as the sandslinger, the jolt-rollover, the squeezer, and others, perform some one or occasionally several of the operations of making the mold from sand or other materials.

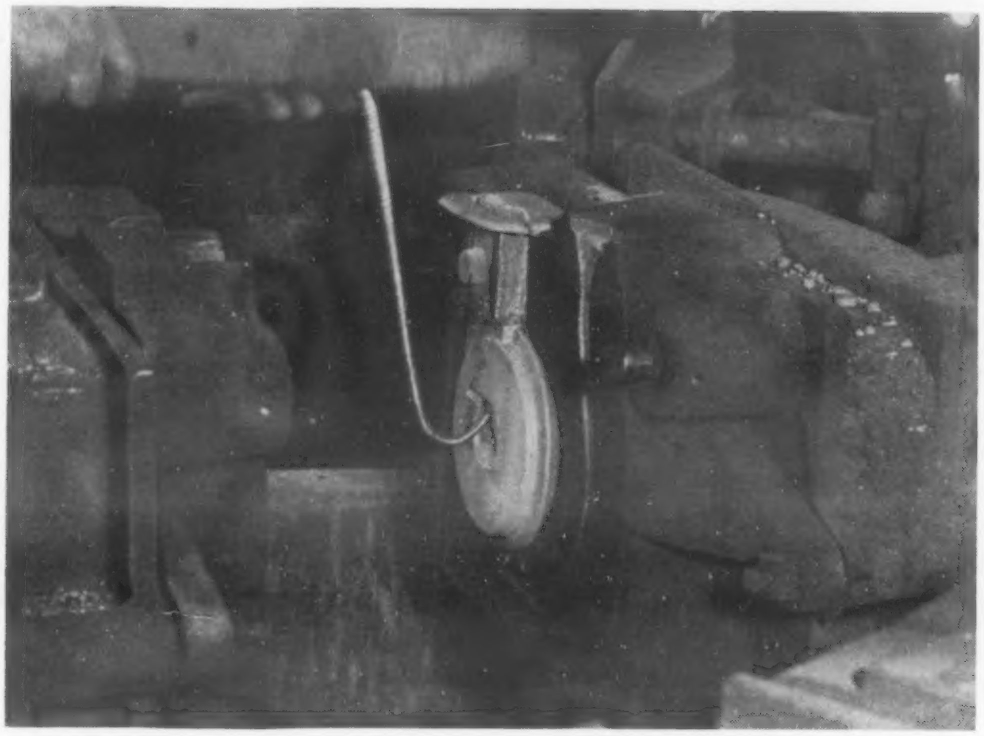
Much progress has also been made in mechanizing the casting process itself. The Foundry Div. of Eaton Manufacturing Co. has perfected and is using a machine that produces gray iron castings in volume in mechanically operated metal molds without the application of pressure. Thus, it brings to the industry the advantages of machine production. Of even greater importance, however, is the fact that castings produced by this method are superior in several respects. These improvements are due to the rigidity of permanent molds, the rapid extraction of heat from the castings, and the uniform temperature maintained throughout the mold during the solidification period.

As a result, permanent mold gray iron castings possess a porous-free structure with sufficient density to hold liquids and gases under pressure in hydraulic and refrigeration units or to contain gasoline. In many cases, such castings have replaced brass and bronze satisfactorily.

The absence of surface hardness and scale and the fine-grained, uniform structure of permanent mold gray iron castings permits easier machining, higher cutting speeds and faster feeds. The saving in machining has been estimated at as high as 15 to 20%. Increased dimensional accuracy also makes it possible to eliminate some machining operations. Growth and distortion are held to a minimum by the uniformity of the metal, making more accurate machining and fitting possible. The fine-grained structure permits surfacing to a mirror finish, if desired.

The Eaton permanent mold machine which produces these castings consists of 12 hollow arms mounted in circular fashion and so connected as to rotate about a central pipe which acts as a hub. At the extreme ends of each arm are inner and outer heads. One-half of a mold is attached to the outer head. The other half is fastened to the inner head, which is movable, being actuated by air cylinders to close, hold, and open the molds. Cooling air passes over both halves of the mold through the hollow arms and into the central pipe, where it is exhausted. On the heads are cams to control the acetylene gas

High production and high quality in cast iron are both provided by a new machine which further helps to mechanize the foundry.



At station No. 5 the mold opens automatically and the casting is removed.

Cores are set by hand after the molds have been coated.

flame that coats the mold with a carbon deposit and also to turn on and shut off an air current which cleans the molds of excess carbon and dirt as the machine revolves.

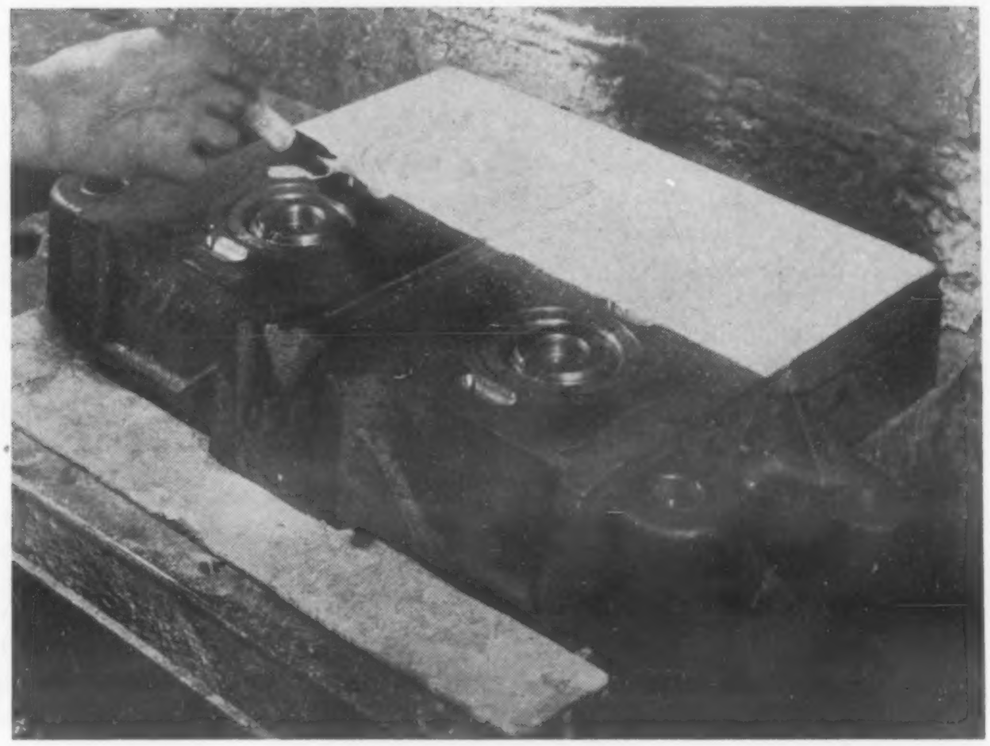
Two men are required in most operations, one to pour the metal, another to remove the finished castings. If the part being cast requires a core, a third man is needed to place it.

Molten metal is brought to the machine by travelling bull ladles, or by whatever other means is convenient for the individual foundry. The rotatable ladle at the machine is filled from the larger ladle, pouring temperatures being held generally to about 2400 to 2500 F. Operations at the machine are then ready to commence.

The mold is poured from the rotatable ladle as the machine slowly revolves. Pouring should be done directly into the down sprue, and any swirling motion of the liquid metal should be avoided as tending to trap air. The top face of the mold must be free from oxide or other foreign material, as this would tend to be carried into the mold.

By the time the fifth arm passes the operator—about 40 to 80 sec.—the metal in the first mold has solidified and cooled. Cams automatically trip the air valve controlling the inner, movable head and its attached half of the mold. The mold is opened, and the casting, cooled evenly to about 700 to 800 F, is removed by the operator at that station with a metal hook.

The remainder of the machine's cycle is concerned with the preparation of the mold for the next pour-



Molds are coated with a refractory wash to prevent actual contact between molten metal and the mold.

ing. The mold first passes in front of a jet of air that cleans the cavity of any loose particles of metal or other material. It then moves under a smoke hood, where acetylene burners deposit a coating of lamp-black over the faces of both halves of the mold. When the casting requires the use of cores, these are placed immediately after the mold leaves the smoke hood. The mold then closes automatically, and comes to the first station again, where another casting is poured.

Physical properties of Gray Iron cast in permanent molds are as follows:

	0.5 in.	*0.875 in.*	*1.2 in.*	*2.0 in.*
Tensile Strength, psi.	52,267	34,142	32,050	22,533
Tensile Modulus, psi. x 10^6	19.53	17.57	13.60	11.98
Brinell Hardness	197	187	180	170
Compressive Strength, psi.	124,342	112,017	119,583	99,783
Torsion, Yield Shear, psi.	—	23,160	19,208	20,208
Torsion, Rupture Shear, psi.	—	43,750	42,186	36,483
Torsion Modulus, psi. x 10^6	—	7.435	6.747	6.310
Transverse Breaking Load, lb.	606	1665	2670	8200
Transverse Deflection, in.	0.178	0.166	0.283	0.240
Modulus of Rupture, psi.	98,950	75,933	70,783	62,700
Bending Modulus, psi. x 10^6	19.60	16.94	14.38	14.87
Endurance Limit, psi.	32,000	20,000	19,500	13,500
Heat-treated Tensile Strength, psi.	82,433	50,250	38,783	32,242
Heat-treated Tensile Modulus x 10^6	19.20	17.40	13.36	10.95
Growth, increase in volume % per cycle	0.133	0.170	0.180	0.330

An electric motor driving a ring gear attached to the hub provides the power for rotating the machine. Once started, the operation is continuous, although switches located near the operator make possible emergency stopping. A variable speed reducer on the motor permits any desired speed from one revolution in 2 min. to one revolution in 6 min.

The speed at which the machine travels is set at such a rate that the molds, which have been preheated to about 700 F, will not cool below 600 to 800 F during the casting operation. When starting the machine, the cycle time should be reduced until the molds become heated slightly above 700 F in operation and then slowed down about 30 sec. per revolution. This is usually the best speed.

Proper control of temperature of the molds and through them of the castings is very important. Because of the preheating of the molds, any excessive chilling of the castings is avoided. A rapid and uniform withdrawal of heat is necessary so that the casting can be removed from the mold within about 1 min. of the time of pouring. Such cooling is also necessary to obtain a uniform distribution of graphite in the casting.

To obtain sound castings, it is important that the charge of the cupola be so adjusted, along with the blast, that the metal at the spout have a temperature of about 2800 F and possess the following composition:

Total Carbon	3.40 to 3.60%
Silicon	2.40 to 2.60%
Manganese	0.70 to 0.90%
Phosphorus	0.30% max.
Sulphur	0.10% max.

The carbon-silicon balance, and the values for carbon and silicon, are especially important in avoiding shrink spots on the face of the casting.

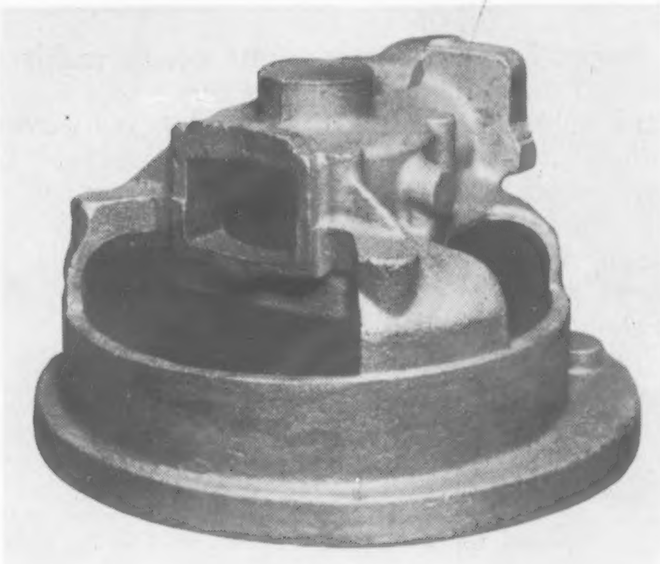
Gray iron of this composition ordinarily has a tensile strength of about 20,000 psi. and possesses rather high graphitic carbon. When cast into permanent molds, however, the metal shows tensile strengths in the neighborhood of 30,000 to 40,000 psi., and strengths as high as 70,000 psi. have been obtained after heat treatment. Brinell hardness is in the 170 to 205 range. As with all cast irons, section size has a bearing upon strength due to the finer division of the graphite in smaller sections. The size factor is not as pronounced in the case of permanent mold castings, however, because of the more uniform cooling rates maintained in the molds.

Deflection under load is unusually high with the permanent mold gray iron castings. The smaller size of the graphite flakes in permanent mold castings makes them more amenable to heat treatment, as solution from the graphitic form occurs more readily.

While permanent mold castings do not possess the hard scale ordinarily found on the surface of gray cast iron, an annealing is recommended to remove the strains associated with quick setting of the metal, and also to soften any small spots of white iron that may have resulted from improperly heated molds or from improper coating. An annealing cycle that has been proved adequate consists of: Heating to temperature of 1575 F in 1½ hr.; holding at temperature for 20 min.; cooling in furnace in 1½ hr.

The molds themselves are made of heat resisting cast iron. They are made in four standard sizes, and are interchangeable. Sizes of castings are limited to 12 in. in length or 12 in. in dia., or to 15 to 18 lb. in weight.

Design of castings to be produced by the Eaton permanent mold process is basically the same as for other types of molding, but differs in a few respects. First, it is important to the life of the mold that the casting cavity be as uniform as possible to permit easy ejecting of the casting and to protect the mold from excessive wear. Second, the permanent mold should have a flat parting line. A small amount of taper or molding draft should be allowed from the parting line to the deeper area at the bottom of the mold cavity.



An example of a gray iron casting produced by the Eaton permanent mold process.

The walls around the mold cavity must be of the proper thickness to permit rapid and uniform withdrawal of heat from the casting, since heat distribution should be uniform throughout the mold if localized hot or cold spots are to be avoided and long mold life and sound castings are to be obtained. A cavity backing of ¾ in. to 1¼ in. is usual.

To assist in heat dissipation, cooling pins about ⅜-in. in dia. cover the back area of each half of the mold. Spacing of the pins is determined by actual experience, number and location being fixed by the need to keep the mold at even temperature.

The down sprue usually divides the mold in the center, but offset sprues are sometimes used. At the bottom of the down sprue is the runner, in a horizontal plane, and usually extending practically across the face of the mold. A gate, of from 0.045 to 0.0875 in., connects the runner with the mold cavity. One cavity may be placed above another in a multiple mold, and the riser from the bottom cavity is the gate for the upper cavity. Risers, shrink bobs, and traps may be located above the top cavities.

The top of the mold is divided into three sections, the center section forming a pouring basis, and the sections at either side serving as pools for the risers. The top is given a 5-deg. slant toward the center of the mold, and rims serve to retain the molten metal in each section.

As the molds are not permeable, sufficient vent must be provided through core prints or in some other way when cores are used. One side of the core print should always face the open air. In exceptional cases relief cuts may be made across the face of the mold for gas relief; as these cuts tend to become filled with soot, they are a last resort only. When the core itself is well vented, and made with an open sand, no difficulty should arise. Vent plugs inserted in the mold cavity assist in permitting gases to escape.

All twelve of the molds used on the machine can be different. The only requirement is that all molds on the machine at one time have the same cooling rate.

To assure mold release, a double coating is applied before the mold is placed in operation, the first application consisting of a refractory mixture painted onto the inner surfaces of the mold. The mixture is composed of fireclay suspended in sodium silicate. Over this is applied a coating of lampblack which is removed automatically by the machine during each cycle of the molds.

The molds are considered to have a life of from 3000 to 10,000 pourings, if properly designed.

Costs of producing castings by the Eaton permanent mold method are competitive with sand castings when the number of parts is sufficient to justify the investment in permanent molds. Five hundred parts will usually warrant making permanent molds.

Though most solvents are toxic by nature, they will not be health or safety hazards if proper ventilation and other precautions are provided.

Here is the setup used by Wright Aeronautical Corp. to clean spark plugs in carbon tetrachloride. Fully exhausted, this hooded rack permits the worker to observe the process through a glass top.

The Safe Handling of Solvents

by LILLIAN GORDON, *Safety Research Institute*

ORGANIC SOLVENTS are widely used in metalworking operations because of their volatility and dissolving power. These properties make them valuable as cleaning and degreasing agents, as the liquid base for sprays, as thinners in paints and finishes, and for similar purposes. If used improperly, however, most solvents present a health or fire hazard, or both. Of course, solvents are not the only potential source of illness in the metalworking plant. Unless there is adequate planning for safety, illness can also be caused by operations involving: lead, as fumes from the melt pot or as dust from buffing and shaping dies; chromic acid in electroplating and anodizing; welding fumes; cyanide compounds in the heat treatment of metal surfaces; silica dust in sand blasting; alkali liquids or mists in metal surface cleaning and degreasing; acids in metal cleaning before electroplating; and cutting oils in machine shop operations.

All these operations can be conducted safely if the proper controls are instituted. In the case of the organic solvents, a well-planned safety program consists of:

1. Indentification of hazardous operations.
2. Analysis of the hazards.
3. Engineering controls.
4. Personal protection of employees.
5. Medical protection.
6. Supervision.
7. Employee education.

Metalworking operations that are likely to involve organic solvents include: spray painting, application of dopes and other finishing operations, assembly processes using rubber cement, degreasing, and other miscellaneous cleaning operations. Commonly used organic solvents are gasoline, benzine, naphtha, petroleum ether, alcohol, benzene (benzol), acetone, and the chlorinated solvents (carbon tetrachloride, trichlorethylene, and perchlorethylene).

Analysis of the Hazards Involved

Before the hazards of a solvent-using operation can be analyzed, it is necessary to have some knowledge of the hazardous properties of solvents.

Organic solvents can cause illness either through inhalation of their vapors (vapor poisoning) or by contact with the skin (dermatitis). Because organic solvents are highly volatile, some vapors are likely to be present in the workroom atmosphere wherever there are solvent-using operations. Thus, workers regularly engaged in these operations may be exposed to the vapors regularly, sometimes daily for 8-hr. periods. In low concentrations, such exposure is not hazardous and will not cause illness. While there is no fixed point at which the amount of vapor in the air becomes dangerous, the approximate limit has been determined for a number of the solvents. This limit, which is used primarily as a guide in obtaining safe working conditions, is known as the "maximuum allowable concentration," or M.A.C., and is expressed as parts of vapor per million parts of air, by volume.

Sometimes, as the result of accident, ignorance, or negligence, large amounts of vapor may be present. High concentrations, for even a short period of time, can cause acute illness or unconsciousness. If the exposure is sufficiently great or prolonged, severe organic injury, and in some cases death, may occur. Ordinarily, however, prompt removal from the contaminated atmosphere and immediate medical attention leave the victim none the worse for his experience.

Chronic exposure—exposure over a protracted period of time to amounts of vapor not great enough to cause immediate discomfort but more than the M.A.C.—is the more difficult problem in industry since this type of exposure can result in serious injury before the cause is detected. Symptoms of chronic exposure are mild at first, usually headache, fatigue, nausea and intestinal, visual or mental disturbances. If the operating condition is overlooked and exposure continues, the illness may become more severe, with resulting injury to the blood, liver, kidneys, or other organs.

Solvents can also cause dematitis, or skin difficulties, if they are in direct contact with the skin. Such contact causes dryness, cracking, and easy susceptibility to infection.

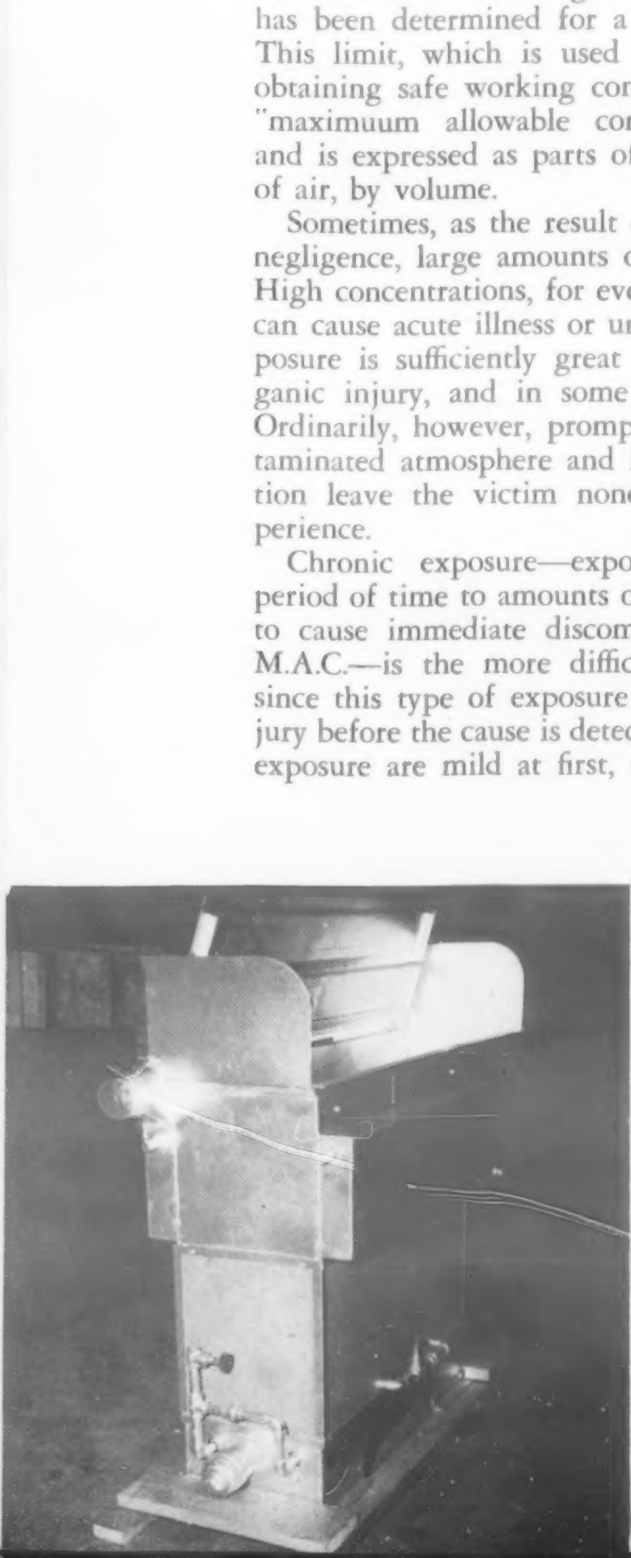
With regard to the danger of fire in solvent-using operations, it is important to note that, of the organic solvents commonly used in the metal industry, only the chlorinated compounds are nonflammable. The flammability of each solvent is a function of its ignition temperature, flash point, volatility, and related properties. The Underwriters' Laboratories has classified solvents according to their "flammability rating." Those with ratings above 40 are serious fire hazards.

In view of these properties of organic solvents, analysis of the hazard accompanying a solvent-using process must include: The effect of the solvent on health, its effect on the skin, its M.A.C., flash point, and flammability rating. This information can be obtained from the manufacturers of solvents or from industrial hygiene agencies. Properties of some of the more common organic solvents are listed in the following table:

Flammable solvents are frequently mixed with carbon tetrachloride or other chlorinated solvents to produce less flammable or nonflammable mixtures. The proportion of chlorinated solvents which must be added to render a mixture nonflammable varies with the other constituents. An investigation by the United States Bureau of Mines has shown that, to be strictly nonflammable, gasoline must contain at least 58% carbon tetrachloride, and other hydrocarbons may require 60% or more. Some other flammable liquids require 75% or more of carbon tetrachloride to become nonflammable.

Two important cautions must be observed in making such mixtures. First, care should be taken that the volatilities of the components of the mixture are not too different. For example, if a chlorinated solvent is added to a flammable liquid which is much less volatile, the chlorinated solvent will evaporate more rapidly, changing the composition of the mixture and leaving the flammable residue. Similarly, if the flammable portion is more volatile than the chlorinated solvent, the vapors of the mixture may be highly flammable, even though the body of the liquid is nonflammable.

A second point of caution involves health hazards. Where a mixture of solvents is used, the physiological effects of each component must be considered in establishing safety controls.



Degreasing unit for manual operation, showing vapor exhaust collar at left. (Courtesy: Mechanical Process Co.)

Engineering Controls

To prevent solvent illness, operations must be designed so that workers will be subjected to the smallest possible amount of solvent vapors during regular operations, will be protected from accidental exposure to high concentrations of vapors, and will

avoid direct contact of the solvent with the skin.

The equipment which most closely fulfills these requirements is, of course, that which keeps solvent operations entirely enclosed, and such equipment is recommended wherever large-scale solvent operations are involved. For small-scale operations, using partially enclosed or open equipment, mechanical ventilation is ordinarily required for safety, unless the operation is very small and in a room with adequate natural ventilation. The Industrial Hygiene Code of the American Foundrymen's Assn. requires mechanical exhaust ventilation unless the degreasing machine or tank has a cross-section of less than 5 sq. ft. and is located in a room of more than 4,000 cu. ft.

Since most solvent vapors are quite heavy, down-draft ventilation, designed to draw the vapors away from, but not past, the breathing area, is required. For degreasing tanks, slot-type lateral exhausts are used along one or both long sides of the tank at the upper edge. For spray booths in which large objects are being sprayed, down-draft exhaust ventilation through a grid-type floor is recommended. Small objects can be cleaned or sprayed in hoods or small booths, with the operator remaining on the outside, if the ventilation is adequate to protect the breathing area. Water-soluble vapors can be removed by means of a water-wash.

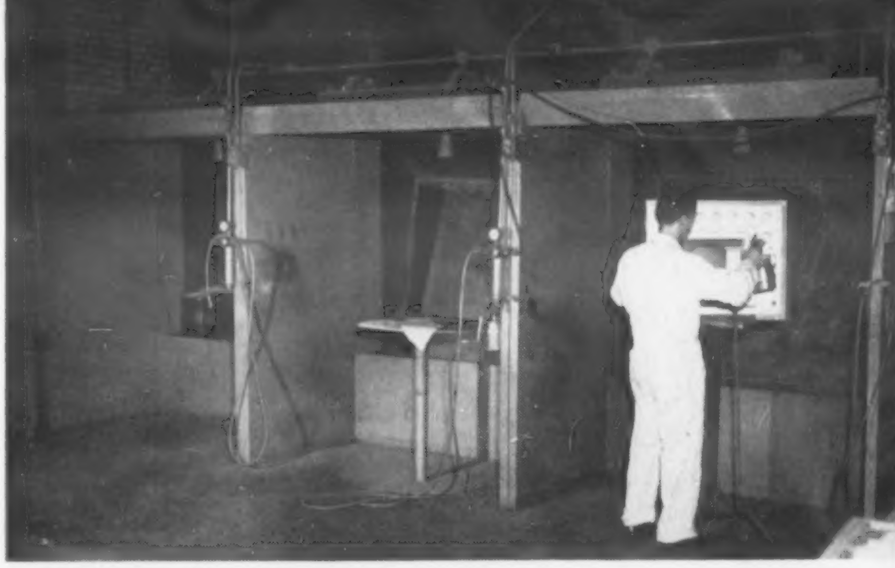
Where ventilating systems are to be installed, it is advisable to consult a ventilating engineer. Many state agencies can also be helpful in this connection. In New York State, for instance, the Plan Examination Office of the Div. of Industrial Hygiene, Department of Labor, passes on all plans for the removal of air contaminants.

Not only installation, but also operation, must be carried out according to the directions of the engineer. In many cases, adequate equipment fails because operations are incorrect. Mechanical ventilating systems are carefully designed for specific conditions and changing these conditions might cancel the effectiveness of the equipment. Thus, turning on fans, opening windows, moving equipment, etc., can cause serious solvent vapor difficulties in an otherwise well-equipped department. Similarly, in the handling of degreasing equipment, it is essential that the operator follow the directions of the manufacturer concerning the load, the rate at which parts are passed through the machine, the time permitted for degreasing, the vapor level maintained, etc.

The adequacy of a ventilating system can be checked by analysis of the workroom air. Chemists, industrial hygienists, or others experienced in air analysis can be employed to provide a periodic report on the vapor content of the workroom atmosphere, especially near dangerous spots, such as spray booths and degreasing tanks.

Enclosed processes which provide for mechanical entry and exit of the treated parts not only protect workers from solvent vapors but also minimize the danger of dermatitis. For other types of operations, it is important to arrange procedures so that parts are not handled while wet. Otherwise, special protective equipment must be provided for operators.

Where flammable solvents are used, ventilating equipment must be of the proper fire-safe design. In addition, special precautions are essential to minimize the danger of fires, as follows:



Spray booths with water wash for removing solvent vapors. Since the paint solvent is flammable, fire protection is also provided. (Courtesy: Pan American Airways)

1. All flames, smoking, and so on, must be eliminated.
2. All sources of sparks must be removed. Rubber-soled shoes should be used, and fan blades and tools should be of nonferrous materials.
3. In spray booths, the booth, floor, baffles and all other parts of the system must be constructed of fire-resistant materials.
4. Surfaces of walls, and so on, should be smooth to facilitate routine cleaning.
5. All electric lights, wiring and other electrical equipment must meet the requirements of the National Electric Code.
6. All equipment for handling flammable solvents, including funnels and portable containers when the latter are being filled or emptied, should be electrically grounded.
7. Main supplies of solvents should be stored in a fireproof storage building, and all mixing should be done in this building.
8. Fire extinguishers, of types approved by the Underwriters' Laboratories or Factory Mutual Laboratories for the class of hazard concerned, should be provided as protection against incipient fires. Built-in fire extinguishing equipment may be needed to safeguard specific hazards of some size, such as degreasing tanks, as well as to afford general building protection.

Personal Protection

To protect operators directly engaged in solvent-using processes, it is often necessary to supply personal protective equipment, including respirators, protective clothing and creams. Such personal protective equipment should not, however, be used as a substitute for adequate engineering controls.

Respirators may be needed as additional protection even where mechanical ventilation is provided, as in the case of spray booth operations. Or they may be employed for small solvent-using processes, like spot cleaning, which cannot easily be provided with mechanical ventilation. Respirators are of the utmost

This closed conveyor protects the worker from exposure to trichlorethylene. The conveyor carries the cylinder head into and out of the solvent.

importance where workers are to be exposed to high concentrations of vapors, even for short periods, as in tank cleaning.

Respirators are of three general types: the "gas mask," which filters the solvent vapors from the air through a canister; the "supplied air" type, which supplies air from an outside source through a hose line; and the "self-contained" type, which carries its own oxygen supply.

The gas mask may be used where the vapor concentration is not above 2%. However, it is important that the filtering substance in the canister be of the proper type to remove organic solvents, and that the canister be replaced as soon as its filtering power becomes questionable. A supplied air respirator, equipped with a 1-in. hose, is recommended where there is high concentration of vapor. The inlet to the hose must be in an uncontaminated area, and if the hose is longer than 25 ft. a manually operated blower should be provided. In some operations, such as spray painting, a source of compressed air, which can be used to supply the respirator, may be available. In this case, the air is supplied through a small diameter (½-in.) hose. But because there is danger of failure of the compressed air supply, such respirators are unsafe to use where rapid escape is not possible, as in tank cleaning.

For tank cleaning, in addition to respirators, it is essential that a life line and watchers be provided.

The self-contained respirator should be used only by men trained in the proper technique and ordinarily is limited to emergency rescue work.

Information about the type of respirator required for any solvent operation can be obtained from the U. S. Bureau of Mines, and only respirators bearing the approval of this agency should be used.

To prevent dermatitis, where hand dipping operations cannot be avoided, appropriate gloves and

Table of Hazards of Solvents

Solvent	M.A.C.* (P.P.M.)	Underwriters' Laboratories Flammability Rating	Flash Pt. (F)
Acetone	200 (Cal., Colo.)	90	0
Amyl alcohol		35-40	114
Amyl acetate	400	55-60	77
Benzene (benzol)	100 (A.S.A.)	95-100	−4
Benzine and gasoline	1,000**	95-100	0
Butyl alcohol (secondary)	100 (Cal.)		82
Butyl acetate	400 (Cal., Mass.)	55-60	72
Carbon disulfide	20 (A.S.A.)	110	−22
Carbon tetrachloride	100	0	None
Cyclohexane			1
Cyclohexanol			154
Dichlorethylene			57
Diethylcellosolve			95
Ethyl acetate			24
Ethyl alcohol	250 (Cal., Colo.)	70	55
Ethyl ether	400 (Cal., Mass.)	100	−49
Ethylene dichloride	100		58
Isopropyl alcohol		55-60	59
Kerosene		40	100-165
Methyl acetate			14
Methyl alcohol	200	70	52
Stoddard's Solvent	**	30-40	100-110
Tetrachlorethane	10	0	—
Tetrachlorethylene	200	0	—
Toluene	200 (A.S.A.)	75-80	40
Trichlorethylene	200	1-2	—
Turpentine	200	40-50	95
Xylene	200 (A.S.A.)		63

** The figures given are as recommended by the Division of Industrial Hygiene, U. S. Public Health Service, unless otherwise indicated, and represent maximum allowable concentrations in the atmosphere for continuous (8-hr. daily) exposure, in terms of parts of vapor per million parts of air, by volume.*

A.S.A. following certain of the figures indicates the limit established by the American Standards Association. Some states have set their own limits which must, of course, be observed in those states.

*** Petroleum solvents can be classified as to health hazard in the following order: naphtha, gasoline, Stoddard's Solvent, F-140, the most toxic being listed first.*

aprons must be provided. For spraying, etc., where solvent may contact the face or neck, protective creams are helpful. Since these creams are water-soluble, they must be renewed after washing. The appropriate type of clothing and cream can be recommended by the manufacturers of these products.

Personal cleanliness is a most important factor in preventing or minimizing dermatitis. An adequate washroom provided with soaps and lubricating creams should be available for employees, and they should be encouraged to wash thoroughly and change clothing at the end of the work day.

Medical Protection

For plants using organic solvents, a complete health program would include preplacement medical examinations, routine medical examinations, and a first aid room with a nurse or physician in attendance.

Certain individuals—alcoholics and those with anemia, liver or kidney diseases—are especially susceptible to solvent illness and should not be permitted to work with these liquids. Similarly, some person may be allergic to a particular solvent, readily developing dermatitis. The preplacement examination can protect both management and employees by discovering such persons before they are assigned to solvent operations.

Regular medical examinations permit early detection of solvent illness, which might otherwise be overlooked or mistaken for some other difficulty, such as an intestinal upset. In this way, the individual is protected from more serious illness, and possible inadequacy of protective equipment can be corrected before other employees become ill.

Prompt medical attention is especially valuable in the case of dermatitis, since early cases can frequently be treated while the individual continues to work. On the other hand, neglected cases of skin disease may require the patient to be absent until the condition clears up.

A first aid room, attended by a nurse or physician, can provide necessary emergency treatment in cases of acute solvent poisoning, and also encourages employees to report early symptoms of illness, thus overcoming a tendency to ignore mild symptoms until serious complications develop.

In case of an accident in the solvent department, the physician or nurse should be notified immediately. For plants which do not maintain a medical department, recommended procedure in case of solvent accidents is as follows:

If a man is exposed to high concentrations of vapors, so that he becomes unconscious, or feels acutely ill, he should be removed to fresh air and a physician called immediately. Never give alcohol to anyone suffering from exposure to a solvent.

If solvent is swallowed, the individual should be made to vomit, and then sent to a physician.

If solvent gets into the eyes, they should be thoroughly washed with water, and then with several drops of clean olive, mineral or castor oil.

If an appreciable quantity of solvent is spilled on unprotected skin, it should be washed immediately, then covered with lubricating cream.

If solvent is spilled on clothing which is not solvent-resistant, the clothing should be removed at once, allowed to dry where no one will be exposed to the vapors, and not worn again until it is entirely free of the odor of solvent.

If a man in the solvent-using department complains of nausea or other signs of vapor poisoning, or of skin irritation, he should be sent to a physician, who should be advised of the type of solvents used in the department.

Supervision

The key to the success of any safety program is adequate supervision. In addition to over-all supervision which coordinates the various parts of the safety program, it is important to have some supervision at a level where close contact with the men is maintained.

It has been found advisable in many plants to assign responsibility for each aspect of the safety program to an individual in the department involved. Thus, the correct operation of the degreasing machine, its inspection, etc., is assigned to a single operator. The turning on of ventilation, inspection for leaks, etc., is the responsibility of another individual in the department. The observation of fire safety rules, inspection of fire extinguishers, etc., are made the specific responsibility of some member of the supervisory staff. The use of respirators and other safety equipment is also carefully supervised, with one person in charge of their distribution, storage, inspection, repair, etc.

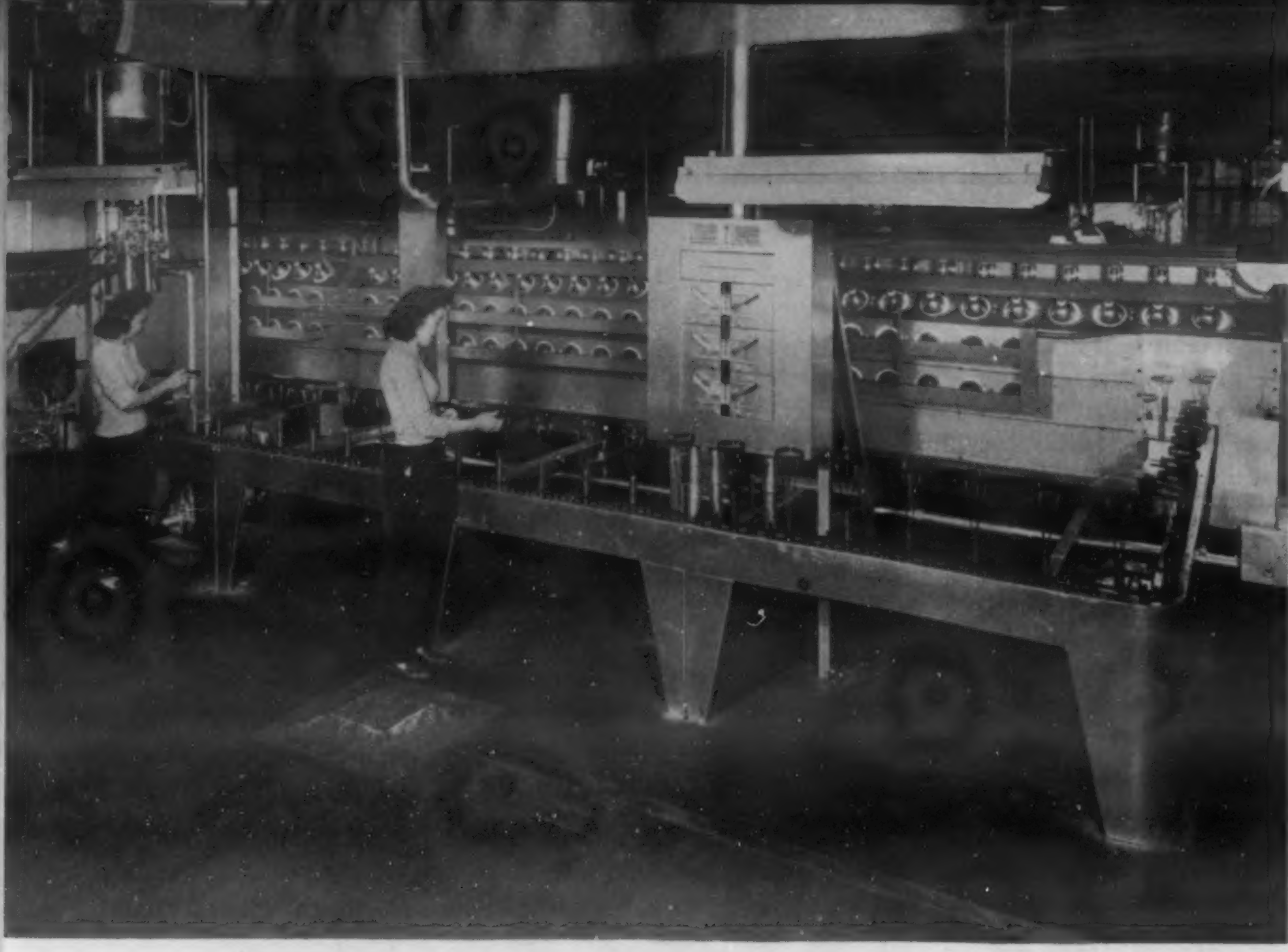
The foremen in direct contact with the men in the solvent departments should be watchful of early symptoms of illness or skin irritation among the men, and should be especially on the alert with new employees.

Employee Education

Active cooperation of the workers in support of the safety program is another important element in assuring its success. Cooperation can be stimulated by giving the men an understanding of the hazards they face and an opportunity to participate actively in certain parts of the program, as in fire brigades, in practice emergency rescue work, etc.

Emphasis should be placed on the importance of using protective equipment properly, reporting signs of equipment failure promptly, reporting early symptoms of illness, and observing recommended rules of cleanliness and diet. Special emphasis should be placed on the fact that the drinking of alcohol shortly before working on solvent operations may predispose the individual to solvent illness.

The education of management and the supervisory staff, whose job it is to institute and maintain the program, should not be neglected. An effort should be made by these groups to keep abreast of the most recent information on industrial safety, as supplied by the manufacturers of solvents and various public health agencies.



In this conveyorized set-up, one operator loads the parts which are finished by automatic spray gun, then carried through the infra-red oven and on to the other operator, who unloads. (Courtesy: C. M. Hall Lamp Co.)

Drying Industrial Finishes on Metals

by H. R. CLAUSER, *Associate Editor*, MATERIALS & METHODS

Introduction

WHICH PROCESS IS BEST for drying, curing and baking industrial finishes—infra-red radiant heating or convection heating? In recent years the pros and cons of this question have been widely discussed. Although the proponents of each of the methods sometimes claim unequivocally that their particular process is best, this is not the answer. The answer is that neither process is a panacea for all finish curing problems. Each has certain limitations and capabilities which define the limits of its usefulness and determine its best applications. It is the purpose in this two-part article to impartially discuss the principles of operation, the characteristics, and the capabilities and limitations of each, and in this way attempt to outline the field of applications for which each appears to be best suited. The first installment will cover the infra-red radiant heating process; the second part, to appear in a future issue, will discuss the convection heating method.

Industrial finishes on metals cure by: (1) evaporation of solvents in the finish; (2) polymerization

This, the first of two articles on heating methods for curing industrial finishes, discusses the pros and the cons of infra-red heating.

(solidification by a chemical reaction in which the molecules "grow-together"), or, (3) oxidation of certain ingredients in the finish. Often more than one curing action is involved. The curing action for any particular finish depends on its nature and formulation.

In general, assuming an adequate fresh air supply to carry off the vapors from the paint and to provide oxygen for any chemical reaction, the curing time decreases with an increase in temperature. Although the drying of paints which cure by natural oxidation (air drying) cannot be appreciably accelerated beyond a certain point by the application of heat, the curing cycle of paints which cure by evaporation and/or polymerization can be considerably shortened.

So the curing of finishes on metal is almost directly dependent upon application of heat to parts being finished. Application of heat to industrial finishes is a matter of heat transfer. There are three ways of accomplishing this: *conduction,* where heat is transferred from the hot part of a body to the colder parts of the same body; *convection,* where heat is transferred by mixing a heated portion of a liquid or gas with a colder portion; and, *radiation,* where a hot body emits heat in the form of radiant energy in all directions. The length of the curing cycle depends upon the quantity of heat furnished to and absorbed by the piece and the finish in a given time regardless of the heat transfer method involved. There is no difference in a unit of heat supplied by any one of the three different methods.

Any discussion of the methods and processes available for efficiently accomplishing the necessary heat transfer in order to cure, or bake industrial finishes on metals involves the consideration of many different factors. In general the major factors to consider include: (1) The types of finishes, and the colors which can be cured; (2) the quality of the cured finish; (3) the speed of the process; (4) the sizes, shapes and thicknesses of parts which can be handled; (5) space requirements; (6) flexibility; (7) working conditions; (8) unit costs. Each finishing job is different and has its special set of requirements to determine which of these factors must be considered, and which is most important. Each application must be considered individually in light of its particular circumstances.

In the discussions of the two heating methods which will follow—infra-red radiant heating in this issue and convection heating methods in a later issue—the major factors listed above will be the basis on which the methods will be described.

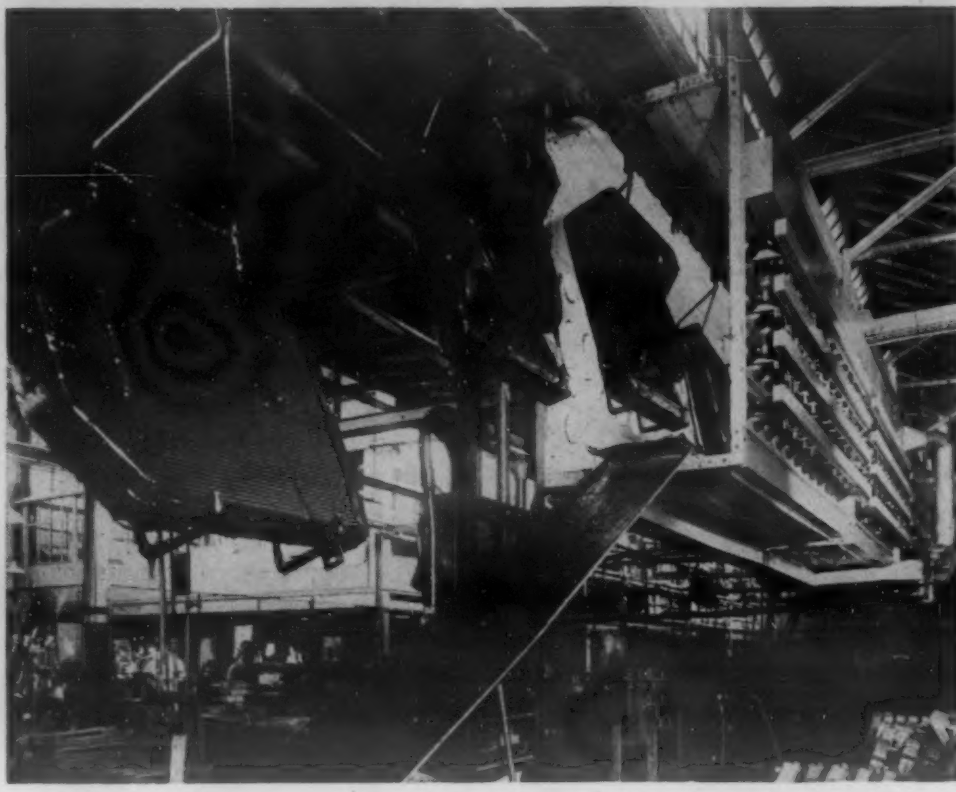
The Infra-Red Radiant Heating Method

Infra-red radiant heating is accomplished by transmitting energy to the object by means of infra-red electromagnetic waves or rays. At the object a portion of the energy is converted into heat. Infra-red rays, whose properties are similar to those of light rays, occur in the electromagnetic spectrum between light rays and outer band of radio waves.

In the use of infra-red energy to cure and bake industrial finishes, radiation is the primary method of heat transfer. However, both conduction and convection also play a part in the heating operation. When infra-red radiation strikes a body, part of the rays may be reflected, part may be transmitted unchanged through the body, and part may be absorbed and transferred into heat. The amount of the energy which is absorbed and transferred to heat depends upon the density of the body, the surface conditions such as smoothness, reflectivity, and color, and the area or angle of exposure to the rays. For example, infra-red on a white object will not create as much heat as on a dark object; a body of steel will get much hotter than a body of cork.

This heat which is created by the infra-red energy is distributed chiefly in two ways. Part of the heat is radiated from the surface of the object and part is transferred by conduction through the mass of the object at a rate governed by the thermal conductivity of the material. If the finish is transparent to the rays, the wet paint film covering a piece of metal offers less resistance than the metal surface to the travel of the rays. Hence, some of the rays penetrate the film, hit the metal surface. The surface heat thus created raises the temperature of the paint to accelerate curing. At the same time heat is transferred through the metal by conduction to the other surfaces where the temperature rise will also accelerate the curing of any finishes present.

The intensity of infra-red radiation on an object is governed by the amount of radiation given off at the source and the distance of the object from the source. The intensity of radiation varies inversely as the square of the distance from the source. The intensity at the source is governed by the watt input into the lamp.



Automobile radiators are cured in about 3 min. in this infra-red oven through which the conveyor travels at a rate of 10 ft. per min. (Courtesy: C. M. Hall Lamp Co.)

The original source of infra-red energy was from lamps built with open type, gold-plated reflectors. With this type of unit, around 97% of the infra-red energy striking the reflectors was reflected. However, efficiency dropped off rapidly, because with use the gold tarnished and alloyed with the base metal of the reflector.

In the early '40's a more satisfactory lamp, the R-40 type, was developed. This is a self-contained unit in which the inner surface of the bulb, covered with vaporized aluminum, serves as the reflector. Thus, efficiency of the lamp remains almost constant throughout its life.

There are two designs of the R-40 type lamp. One has a tungsten filament and the bulb is filled with an inert gas. The other has a carbon filament and the interior of the lamp is a vacuum. The former is preferred. With tungsten, higher operating filament temperatures (around 5000 F) are possible resulting in a more rapid heat transfer. Carbon sublimates more rapidly than tungsten and causes an earlier blackening of the bulb. With the tungsten type lamp the efficiency (ratio of radiant energy output per watt input) is 99% after 1000 hr. as compared to 95% with the carbon type.

Although electric lamps are most commonly used for infra-red heating, a method of producing infra-red energy with a radiant ceramic gas burner has been recently developed. Here, a ceramic cup is heated by a gas-air flame to between 1700 and 2000 F. The ceramic cup becomes incandescent and gives off infra-red energy.

Process Design Considerations

In the curing or baking of industrial finishes on metal it is obviously desirable to heat the finish to the baking temperature as quickly and uniformly as possible. The infra-red radiant heating process is inherently a rapid heating method, but it is not, in itself, a very uniform heating method. Besides this, electricity is still, in most cases, higher in cost than other common sources of heat energy. Therefore, achieving the optimum use of the process is a matter of prudent design and engineering.

The earliest infra-red installations for curing finishes consisted of merely an assembly of lamps in an open space. Indeed, this type of installation is still common, and may or may not be satisfactory depending upon circumstances in each particular case. For example, where a highly portable unit is desired, an open bank installation is often quite satisfactory.

Open-bank set-ups, however, have certain shortcomings. Without forced circulation of air and ventilation there will be some stratification in temperature which results in non-uniform heating. Lower portions of work passing through the unit will be at a lower temperature than the areas higher up. In addition, without ventilation there is no means of eliminating fumes and volatiles evaporated from the paint during curing.

The rate of temperature rise as well as the final temperature in a part depends to an appreciable degree on the temperature of the air surrounding it (ambient air temperature). Because of this, it is obvious that in an open-bank installation with cold air constantly entering the area, thermal efficiency will be low. Absence of an insulated enclosure to retain heat energy also results in high heat loss and consequent low thermal efficiency.

In the most modern infra-red oven designs these undesirable factors have been considered and corrected by enclosing lamps in an insulated oven. In many of oven designs both radiant and convection

Stainless steel caps are joined to ice cream cabinets by use of rubber cement which is plasticized at 250 F in infra-red ovens in 5 min. (Courtesy: C. M. Hall Lamp Co.)

heating principles are used to advantage. The infra-red source is applied to secure maximum rate of temperature rise, while convection heating is used to assure uniform heating and at the same time increase thermal efficiency by recirculating heated air through the oven. In some installations where radiant energy is not sufficient to heat the surrounding air as well as the parts, additional heat sources such as gas are used. This is particularly true in cases where large amounts of solvents or vapors must be exhausted.

Another recent improvement has been the introduction of multiple zone ovens. These multiple zone ovens involve a minimum of two zones, the mass heating zone and the holding zone. In the mass heating zone the part on which the finish has been applied is raised to the desired curing or baking temperature in the shortest possible period by infra-red radiant heating. In the holding zone, only sufficient heat energy is supplied to the work to hold the temperature attained in the mass heating zone. For example, in the baking of a black enamel on a cold rolled steel panel 0.031-in. thick, the full baking temperature of 350 F is achieved in 2 min. using 375-watt R-40 tungsten filament lamps in the first zone. To maintain this temperature for the duration of the baking cycle only 250-watt R-40 lamps are required in the holding zone.

Actually, infra-red ovens can be designed with any number and type of zones to satisfy the particular needs of a job. Installations with four zones are common and can be used to advantage for curing synthetic enamel on metal parts. A four-zone oven usually includes a pre-heating zone which utilizes hot recirculated air to preheat the work and partially boil off highly volatile solvents. The second zone may be the mass heating zone where the work is brought up to temperature; the third section is a holding zone. The last section in a typical installation would be the retention zone with no lamps and with the residual heat of the work and surrounding heat air used to complete the curing cycle.

Parts Determine Installation Type

Like any industrial process involving heat or temperatures, design of an infra-red heating installation is largely governed by the end product. A finish is formulated to be cured or baked at a given temperature (or range of temperature) for a definite time. In infra-red installations this is achieved primarily by controlling intensity of the infra-red source and the time the finish is subjected to radiation. The ideal installation is one in which there is one type finish and one thickness to be processed. However, most installations are not that simple, but must be able to handle different kinds of parts each having a different finish and section thickness as well as a different shape. These changes are taken care of by varying wattage of the lamps (and diameters of the reflectors, if separate) and increasing or decreasing conveyor speed. In some cases where different heat densities are required on the same finish, the several heat densities are achieved by zoning the oven. For example, certain types of wrinkle finishes require a low temperature until the wrinkle pattern is set or formed. In such cases the first portion of the oven would be equipped with low-wattage lamps to provide necessary low temperature; the last portion would have high wattage lamps to provide the higher temperature zone to complete the baking cycle.

Since the infra-red process is a high speed method of heating, it is a generally accepted fact that any system in which it is used as the heat source should be conveyorized. There are some applications where

a batch system is applicable, but in most cases the use of infra-red is not justified where the material cannot be handled by conveyor means.

To summarize briefly, for optimum use of the infra-red radiant heating method in curing or baking industrial finishes, ovens should have the following design features:

1. Be entirely enclosed and adequately insulated for heat conservation
2. exhaust facilities to remove volatile products released from the finishes
3. possess a controlled atmosphere to prevent temperature stratification and provide ambient air temperatures approaching those of the parts
4. be zoned and the various zones supplied with recirculated heated air wherever applicable
5. be conveyorized.

Capabilities and Limitations

The principal advantage of infra-red radiant heating is its ability to concentrate heat directly on the part and finish being cured or baked. Thus, the part is rapidly heated up to the curing or baking temperature. This makes possible shorter baking, curing or drying cycles which in many cases means faster or increased production. It may also permit the use of smaller sized ovens and thus reduce initial cost and decrease space requirements. However, it must be kept in mind that in many localities electricity is an expensive item, so shortening of the finishing cycle must be sufficient to justify the high heating cost of electrical energy.

In some applications radiant heating does a better quality job. In the finishing of some products a circulating atmosphere might set up internal heat stresses and cause distortion, compression or otherwise damage the parts. For example, the use of infra-red is advantageous on products with thin webs to avoid curling of the webs. Radiant heat also eleminates to a large degree case hardening of finishes.

Assuming a properly designed and engineered installation the radiant heating method has flexibility and good control. An installation at the C. M. Hall Lamp plant illustrates this. Here a variety of metal housings are processed through a 27-ft. long oven. A 6-branch distribution panel makes possible a range of 15½-Kw minimum to a maximum of 95-Kw. Intensity of radiant heat is varied within this range depending upon such factors as color, size, and type of finish of the product to be processed.

The type of finish is an important factor in the consideration of infra-red radiant heating. Not all types of industrial finishes are suitable for curing or baking with this process. In general, curing of finishes that utilize an oxidation reaction cannot be accelerated sufficiently to warrant the adoption of infra-red. Those finishes that cure primarily by polymerization or by evaporation are generally suitable to the infra-red process. For example, many of the synthetics cure through polymerization and are well adapted to short-cycle curing.

Color of finish is another important consideration. Careful attention is required because rapid heating provided by infra-red easily can cause overheating with consequent discoloration. In all cases it is important to have the finish formulated specifically for infra-red curing.

Multicolored finishes on the same part are usually difficult to handle satisfactorily. For example, the dark finish on a part will heat faster and reach a higher end temperature than a lighter portion. In such a situation there is danger of not obtaining the proper range of curing or baking temperatures for the different colored finishes. Special formulation of varied-color paints is sometimes possible to equalize curing temperatures. In other cases difference in wall thicknesses may tend to equalize the inherent temperature differences caused by the different colors. However, in general, the infra-red process is not applicable to multicolored objects.

Since infra-red energy distribution is subject to most of the laws that control light, its use is influenced by such things as the surface conditions, and the shape and dimensions of products being processed. All factors must be analyzed when considering the possible applications of infra-red radiant heating. Finishes on metals with a high surface luster, such as many of the copper alloys, magnesium, silver, gold, and aluminum (in some cases), are not so successfully cured by infra-red as are such materials as steel or iron where the surface is dull and the reflectivity is relatively low.

Infra-red radiant heating is most suitable for curing finishes on parts whose shape and mass are such that all surfaces get approximately the same intensity of radiation. Flat sheet forms with equal wall thicknesses are particularly applicable; irregular shapes with shaded or hidden surfaces, or parts that vary appreciably in wall thickness cannot be processed best by radiant heating. There are no specific limitations on the size of the work which can be handled. Installations are in use for products as large as box cars and items as small as lipstick holders. With extremely small objects it is sometimes difficult to expose all surfaces to direct radiation, and it is more practical to heat them in baskets by convection methods.

In conclusion, it can be seen that the infra-red radiant heating process is a high-speed heating method which can be used to advantage in many industrial finish baking applications. But it is not a cure-all. Each application must be considered individually; the many factors which are involved in any finishing problem must be considered in the light of the capabilities and limitations of infra-red radiant heating. Where the finish curing job favors this method of heating, it will result in shorter curing cycles and often result in space savings and lower unit costs.

Acknowledgment

Acknowledgment is made for the assistance given by the following organizations:

C. M. Hall Lamp Co.
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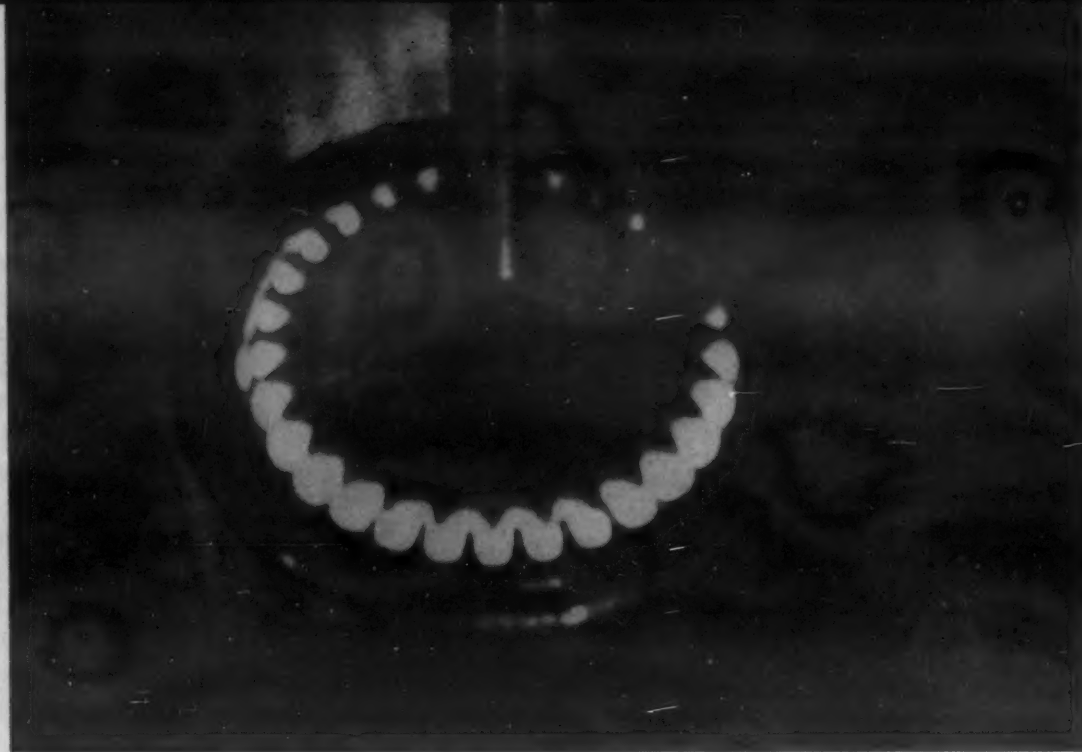

Fig. 1—A 3-in. diameter, ½-in. face spur gear being heated to hardening temperature in 3 sec. with a 200-kw., 450,000-cycle oscillator.

Induction Heating Applied to Steel Gears

by T. H. GRAY, *Research Engineer, Research Laboratory, Westinghouse Electric Corp.*

HEAT TREATMENT OF GEARS by the induction heating method simplifies their manufacture in two ways: first, heat-treating schedules are reduced from hours to seconds; and second, stock removal after heat treatment is reduced from tenths of inches to thousands of inches with an attendant decrease in time for finish machining, grinding and lapping.

The desirable characteristics of the application of the induction heating process to gear heat-treatment arise from the localized heating produced by high frequency eddy currents and the rapidity with which the heating can be accomplished. This is illustrated in Fig. 1, a photograph of a gear being heated to quenching temperature in 3 sec.

Cited here are several examples of how induction heating is advantageously applied to gearing to speed output and reduce finishing costs.

Distortion, almost synonymously associated with conventional heat-treating processes, is in general greatly reduced, and in recent developments completely eliminated by the application of heat to only those portions of the gears where hardening is desired. The cold, unheated sections of the gear, namely the hub, the web, and sections of the rim below the teeth, prevent the major distortions which tend to result from thermal gradients set up during the quench. Thin contour-hardened zones reduce to a minimum the dimensional changes inherent with the hardening transformation phenomena. With reduced distortion, the subsequent finishing operations, *e.g.*, machining, grinding or lapping, are greatly simplified. Very often it is the man-hours and expense entailed in finishing gears after heat-treatment that constitutes the greater proportion of overall cost of gear manufacture.

Elimination of machining operations after induction heat-treatment allows the use of higher hardnesses at the working surfaces of the gear teeth. Higher hardness in turn increases resistance to wear, enhances fatigue strength, and may permit higher working stresses than would be practicable for gears heat-treated in conventional ways.

There are several heat-treating procedures by which

Fig. 2—This 26-in. diameter, 5-in. face drive gear was inductively heat-treated at the Caterpillar Tractor Co. in 90 sec. at 9600 cycles.

induction heating is advantageously applied to gears as follows:

Contour-Hardening Based on Critical Cooling Rates

One procedure utilizing the specific depth hardenabilities of low and medium carbon steels in conjunction with localized heating as provided by induction heating has been successfully applied to contour-hardening gears possessing teeth of large cross-sections. In this procedure the contour-hardened surface zones are the results, not of applied contour heat patterns, but of limited depths of hardness penetrations governed by the critical cooling rates of the steels employed. Cooling rates, in turn, are dependent on the composition of the steels, the amounts of heat applied, and the rates at which the heat is extracted during the quench. With proper control of these three factors the actual cooling rates produced by the quench can be made to equal the critical cooling rate of the particular steel at the desired depth of hardness penetration and thus produce a contour-hardened zone of the proper thickness.

Induction heating large tractor gears of SAE 1045 steel to obtain contour-hardening by this procedure has been successfully practiced by the caterpillar Tractor Co. for several years. Illustrated in Fig. 2 is a 26-in. dia. tractor driving gear with a 5-in. face being heated while rotating in a 4-turn inductor coil. The heating cycle consists of preheating the gears to 600 F in an electric furnace with forced air circulation and then induction heating the peripheral face to a considerable depth below the roots of the teeth to a temperature of 1550 F in 90 sec. The gear is then lowered into a quenching fixture and water-spray quenched after a delay of 14 sec. A maximum of 500 kw. of 9600-cycle power, supplied by rotating electrical equipment, is required to heat the gears.

A very satisfactory hardness pattern is obtained on this gear with the above described heat-treatment. Fig. 3 shows the contour obtained with the inner edge of the hardened zone possessing a minimum hardness of 50 Rockwell C, penetrating to 0.108 to 0.132 in. at the pitch line. Because of the close control of the critical cooling rate, this contour was obtained in spite of through-heating the teeth.

The many advantages gained by application of this type of induction heating to large gears are exemplified by the cited example. The most important is that short service life of gears is overcome by the greatly increased resistance to wear. Secondly, a considerable reduction in material cost is obtained by the replacement of a more expensive alloy steel by a carbon steel. Additional savings are obtained by reduction in tool wear and by the increased machineability of carbon steels. A further advantage is that the desired contour of the gear is machined while in the soft and machineable condition, and this form maintained during heat-treatment. Out-of-roundness of the 2-ft. dia. gears, after induction hardening, is on the average 0.007 in. at pitch diameter.

Contour-hardening by the method described cannot be successfully applied to small gears where the depth of hardening permitted by the hardenability of the steel is equal to or greater than one-half the thickness of the tooth at the pitch line.

Through-Hardening of Gear Teeth

A second type of induction hardening procedure, that of through-hardening of the teeth to a short depth below the roots, has been successfully applied to alloy steel gears. An example is the hardening of SAE 4140 gears, 5¼-in. in dia. with a 1-in. face (Fig. 4).

In this particular application the hardness specifications are not severe. The requirements are that the teeth and a peripheral zone of approximately 3/16-in. radial depth below the roots be hardened to 46 to 51 Rockwell C. The remainder of each gear is to remain unhardened at a hardness of 28 to 30 Rockwell C.

The gears are heated to the required depth in 60 sec. with a power input of 15 kw. at 9600 cycles. The hardness zone obtained is shown by Fig 5. The structure produced in the teeth and at the roots is that of fine martensite, indicating a well-hardened structure (Fig. 6).

Several advantages are gained by the use of induction heating for hardening these gears. It is possible to maintain exactly the pre-hardening dimensions of the bore and splines during the heat-treatment with a resultant saving in machining cost. The relatively short heat-treating cycle prevents the formation of scale and decarburization, and the combination of alloy content, oil quenching, and shallow depth of heating minimizes overall gear distortion to such an extent that further machining operations are unnecessary.

The residual stress distribution of gears with through-hardened teeth is not as favorable as it is in contour-hardened gears. With a thin contour-hardened surface zone and a soft core, the surfaces of the

teeth and roots are placed under compressional stresses due to the lower density of the hardened steel in the surface zone. Under the bending type of loading to which gear teeth are subjected with resultant tensional stresses imposed on the tooth surface, the residual compressive stresses must be overcome before the teeth will be stressed in tension, the gears thus gaining in over-all strength proportionally to the amount of compressional stresses placed on the tooth surface by the heat-treatment.

High compressional stresses cannot be introduced in the surface layers of gear teeth through-hardened to a depth below their roots due to the lag in transformation of the more deep-seated metal upon quenching. The thermal gradient causes the surface metal to cool first, and its transformation and associated density change is completed before that of the underlying metal. As the underlying metal completes its transformation, it must expand against an already cold, hard brittle surface shell, placing the shell under tension and itself under compression. Depending on the depth of metal hardened below this surface, the stresses within the surface shell can be varied from a highly compressive state to a highly tensional state. This can be demonstrated by partially sectioning gears hardened to various depths below their surfaces. The amount of closure of the gaps will be a function of the depth of hardening.

When the teeth of gears are through-hardened by induction heating, the combination of localized heat, use of alloy steels, and the use of oil quenching is required to minimize the effects of the unfavorable stress distribution. Otherwise, quenching failures may occur, together with subnormal fatigue strength and distortion of the gears, if any one factor of the above combination is missing. Through-hardening the teeth is not recommended if water or brine is to be employed for quenching.

Induction Heating of Carburized Gears

A procedure combining the carburizing process and the induction heating process has been successfully applied to certain gears where high wear resistance and high strength is required. In one application for a motor car company, the peripheral faces of low-carbon steel gears were carburized in the conventional manner and the gears then finish-machined to their final dimensions. The gears were inductively heated with 45 kw. of 450,000-cycle power and water quenched. This treatment produced a thin, uniform peripheral contour-hardened zone of a depth corresponding to that of the carburized case.

When inductive heating these gears, the teeth and a zone slightly below the depth of the case at the roots are through-heated to the quenching temperature. This shallow depth of heating prevents overall distortion of the gear while the shallow case depth of the hardened steel minimizes distortion of the teeth resulting from changes in density. A very favorable stress distribution is produced at the surface. Such a contour-hardened gear, possessing maximum hardness, high compressive stresses, and almost zero distortion, is shown in Fig. 7.

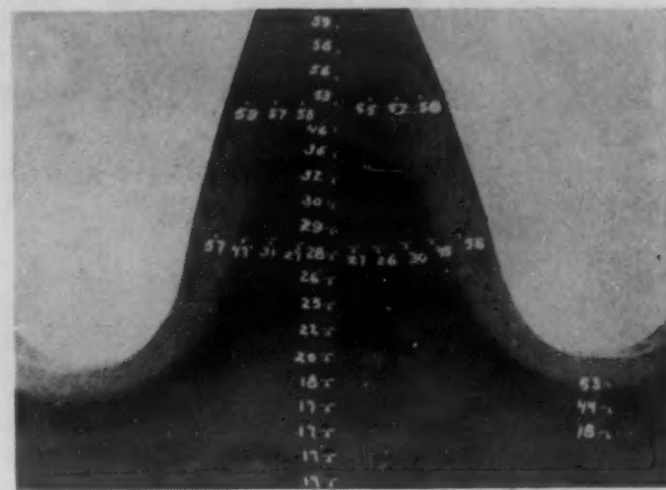

Fig. 3—Hardness contour produced on 26-in. diameter, 5-in. face drive gear by induction heating at Caterpillar Tractor Co.

Fig. 4—A 5¼-in., 1-in. face gear of SAE 4140 steel through hardened by induction heating.

Fig. 5—Hardness zone depth of induction heated gear of SAE 4140 steel.

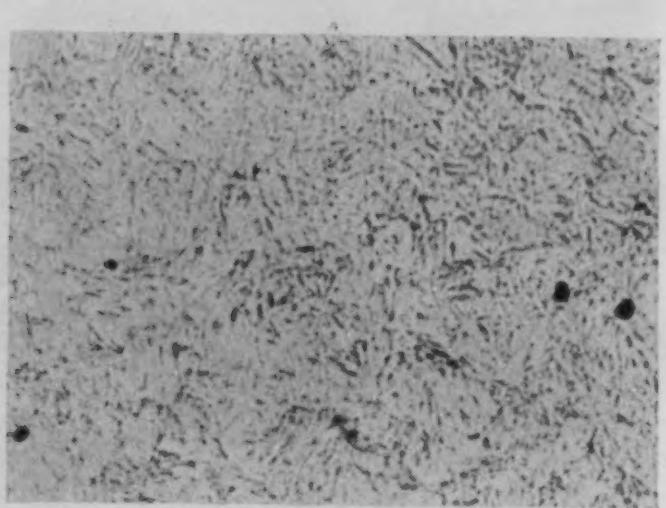

Fig. 6—Microstructure of induction hardened SAE 4140 steel gear. Hardness 600 DPH (500X).

Individual Tooth Hardening

Many gears are of such size that the amount of power required to heat all portions of the peripheral surface simultaneously would be prohibitive. For example, the power input required to heat a 40-in. dia. gear with a 6-in. face to its hardening temperature is approximately 660 kw. The power input to the motor driving the generator furnishing the HF power would be approximately 1100 kw. This value of 1100 kw. input to the motor driving the generator is based on the assumption that only 60% of the power applied to the motor is actually generated as heat within the gear.

The power input to the gear required can be calculated from the thermal equation:

$$KW = \frac{Sp.ht. \times Wt. \times \triangle t \times k}{T \times 1000}$$

where

Sp.ht. = Specific heat of the steel = 0.157 Btu. per lb. per degree F

Wt. = Weight in lb. of the steel heated = 243 lb.

$\triangle t$ = Rise in temperature = 1472 F

K = Constant to change Btu.'s to watts = 1054

T = Heating time in sec. = 90 sec.

1000 = To change watts to kw.

Because of the large demands of power required for over-all hardening of large gears, there is a field of application for individual tooth hardening or for hardening a small group of teeth at a time. The limiting factors in such applications are the size of the gear teeth, the design of the inductor coil, and the amount of high frequency power available. With sufficient power (much below that required for over-all heating) and large enough teeth to enable an inductor coil to fit between them or around an individual tooth or around a group of teeth, contour hardening of single teeth has been successfully practiced.

The disadvantages to the process of individual tooth hardening are that it is relatively slow as compared to over-all heating, and adequate provisions must be made for properly quenching the heated areas. In spite of the disadvantages the process is being used effectively in several applications.

Contour Hardening Per Se

The ultimate solution to the problem of heat-treating gears is by over-all contour-hardening by high frequency heating without recourse to hardenability properties of the steel or supplementary treatments, such as carburization. An experimental application of high frequency heating to a small gear is illustrated in Fig 1, which shows a 3-in. dia. gear being heated to hardening temperature in 3 sec. with a 200-kw. induction heating oscillator. For fine pitch gears, this time is relatively long, as studies have indicated that the heating period should be of the order of 1 sec. or less. Up to the present, production of contour-hardened gears by this method has been limited by the quantities of high frequency power available and the cost of the necessary electrical apparatus. However, with power now available in blocks of 200 kw. and more at frequencies in the neighborhood of 500 kc., the first real attack on the problem of contour surface hardening gears by induction heating has begun, and it is anticipated that in the not too distant future gears up to 10 in. in dia. will be successfully contour-hardened in production by this process.

The technical advantages of this process are manifest. The reduction of the heat-treating time from hours to seconds and fractions of seconds, the production of gears of maximum surface hardness and most favorable stress distribution, the prevention of heat-treating failures, the curtailment or elimination of finishing operations after hardening, and the establishment of automatic and continuous heat-treating procedures are all goals well worth striving for and ones which are now approached because high-power high-frequency electrical equipment has become commercially available.

It is unlikely that these goals will be reached at once for gears of all sizes and types because some of the problems that stand in the way are not easy of solution. However, the tools are now at hand and successful results have been obtained.

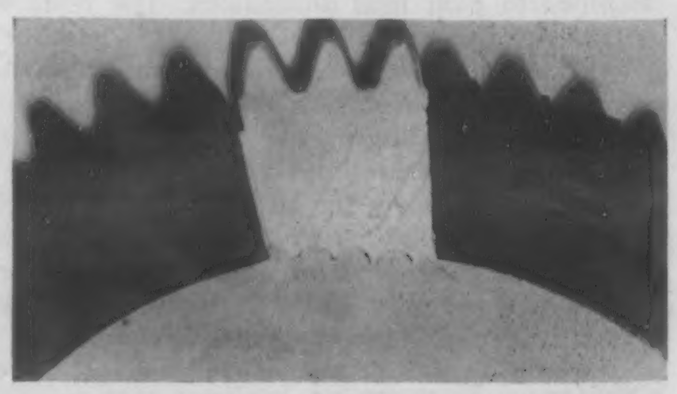

Fig. 7—An 8 pitch, 7-in. diameter, ¾-in. face carburized transmission gear induction heat-treated with a 45-kw., 450,000-cycle oscillator.

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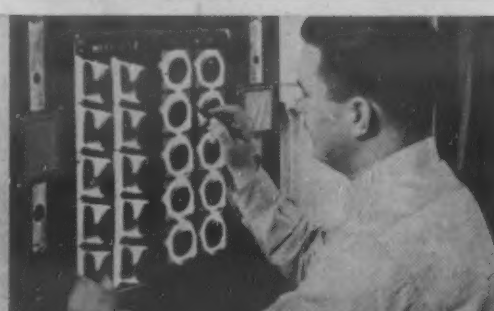

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MATERIALS & METHODS MANUAL 20

This is another in a series of Manuals on engineering materials and processing methods, published at periodic intervals as special sections in Materials & Methods. Each of them is intended to be a compressed handbook on its particular subject and to be packed with useful reference data on the characteristics of certain materials or metal forms or with essential principles, best procedures and operating data for performing specific metalworking processes.

Precision Grinding

by Robert S. Burpo, Jr.,

Associate Editor, MATERIALS & METHODS

The increase in use of hard, difficult to machine materials, a general tightening up of tolerances and the desire for ultra-smooth finishes on machined parts has spotlighted the role of precision grinding in the modern production picture. This manual describes and outlines the range of uses for the principal types of precision grinding machines. In addition, interesting and valuable case studies are given to illustrate the capabilities of these grinders.

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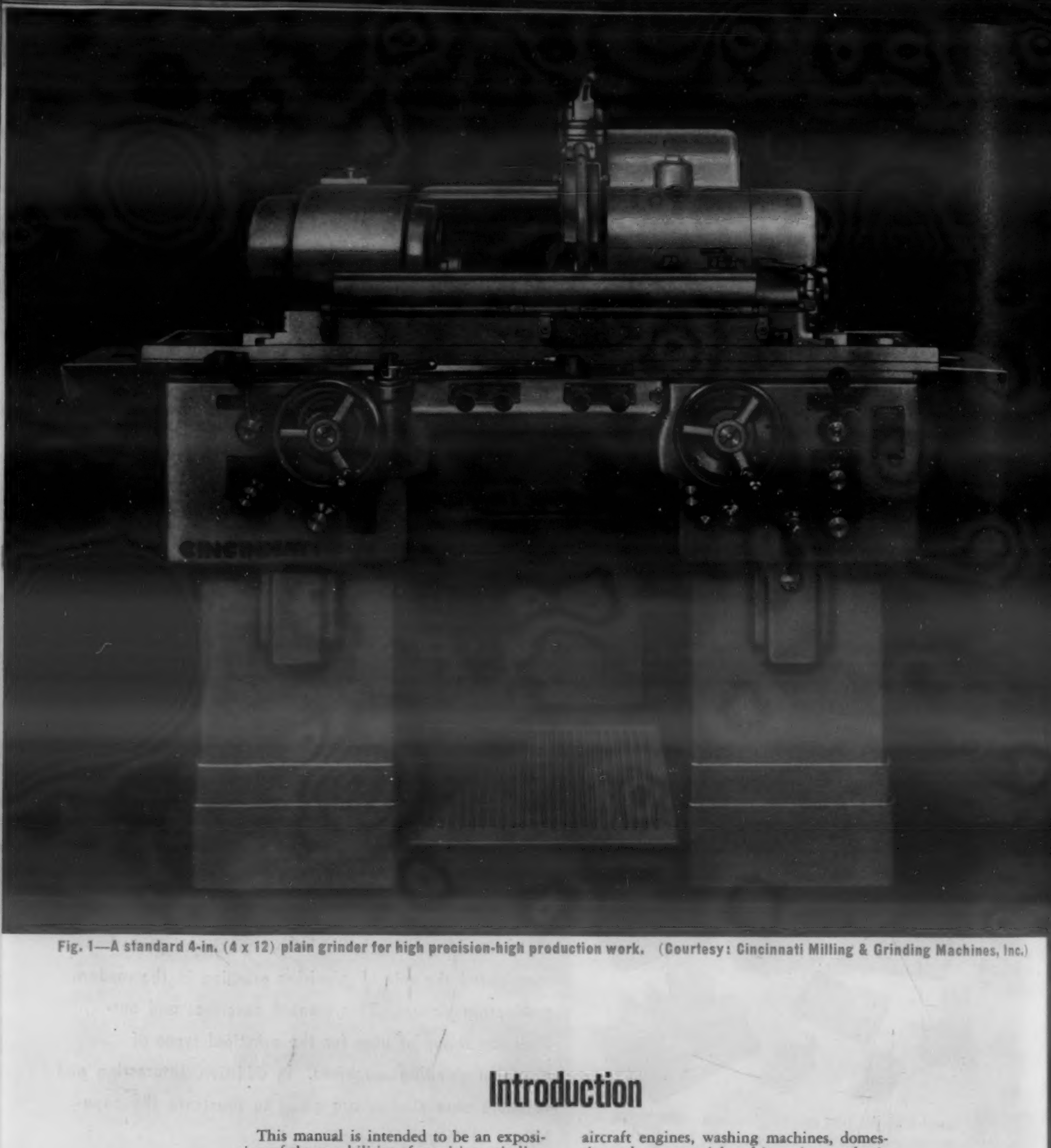


Fig. 1—A standard 4-in. (4 x 12) plain grinder for high precision-high production work. (Courtesy: Cincinnati Milling & Grinding Machines, Inc.)

Introduction

This manual is intended to be an exposition of the capabilities of precision grinding as a modern industrial tool. Various types of grinding machines will be discussed from the manufacturing methods viewpoint. Their utilization as one of the most important tools in present-day production procedures and their places in factories, whether they are mass-production plants or precision job shops, will be described in practical and accurate terms. In order to keep this manual within its prescribed size, only precision grinding will be considered; off-hand grinding, snagging, tool sharpening and regrinding will not be included because of the space limitations.

Neither our present manufacturing practices nor many of our mass-produced mechanical products (such as automobile and aircraft engines, washing machines, domestic and commercial refrigeration and air conditioning equipment, motors and other electrical devices, military materiel, machine tools and many other items), would be possible without the use of today's rapid, precision grinding equipment and techniques. Materials too hard to be cut can be finished by grinding; surface finishes and geometrical and dimensional accuracies unheard of previously can be produced by the proper use of bonded abrasive wheels. Practically any engineering material can be ground efficiently: glass, natural and synthetic hard rubber and plastics, either hard or soft steels, powder metallurgy parts, sintered carbides, ceramics, cast and wrought irons, nonferrous metals and alloys, and dozens more.

Precision Grinding Machines

Prior to considering the uses and capabilities of the various types of precision grinders, a brief description of each will be given. The employment of each of these different types of machines in modern industrial plants will then be described in detail in a later section of this manual.

Basically, all precision grinders can be reduced to: a way of holding or supporting the work piece, an abrasive wheel and a suitable means of supporting, driving and feeding the wheel. There are many different styles and compositions of abrasive wheels, and a few brief comments on this important topic would not be out of order.

The grinding wheel is too important a part of the precision grinding machine to be neglected in this manual, yet the properties of wheels and their selection is a complete manual in itself, so the space devoted to abrasive wheels will be very small.

Grinding wheels must be chosen carefully for each type of job and machine. Wheels for precision grinding are themselves precision made, and consist of sharp abrasive particles bound together by a bond. Irrespective of who manufactures them, most of the wheels contain either aluminum oxide or silicon carbide abrasive particles. The five common bonding processes are vitrified, silicate, resinoid, rubber and shellac. For the particular virtues and uses of each, the reader is referred to the several grinding wheel manufacturers.

By the proper selection of abrasive wheel, a wide range of surface finishes can be obtained (assuming that the grinding machine is not subject to vibration or distortion as these cause chatter marks to appear on the surface of the work-piece). The finest of these finishes was formerly obtainable only by lapping, but these now are economically produced on precision grinders if the appropriate wheel is used.

Precision grinders must be massive and they must be constructed of a high-damping-capacity metal such as cast iron. Fabricated steel structures have not been generally successfully used as machine bases and other important parts because they tend to transmit vibration too readily; vibration and deflection both must be guarded against.

The methods of supporting the work differ with the type of machine. Besides supporting the work-piece between centers, there are numerous types of work-holders and chucks available; mention of these will be included in the discussions of particular machine types which follow.

Precision grinding machines will be grouped under the following headings for discussion: cylindrical, universal, surface, internal, centerless, thread, and specialized grinders.

Plain Cylindrical Grinders

(Also called cylindrical or plain grinders)

The size of plain grinders is expressed by terms such as 3 x 12, 10 x 48 in., etc. The first number denotes the nominal swing over the table and the second, the capacity between centers. The use of workrests (backrests or steadyrests) will decrease the diameter of work that can be ground in a given machine. Actually, a 3-in. plain grinder has a maximum swing over the table of almost 4 in. The size of the grinding wheel also effects the size of work-piece that can be ground.

Plain grinders are made in a variety of sizes from 4 x 12 in. to 60 x 480 in. The larger sizes are often called roll grinders, but since these are not commonly used in manufacturing, they will not be discussed.

The type of work that can be ground on a plain grinder is usually limited to the OD of cylindrical work-pieces; shoulders may be squared also.

Usually the work-pieces are held between centers or on an arbor in plain grinders; in the case of live spindle headstock machines, chucks, cat heads, collets and similar work-holder devices can be used.

A modification of the standard plain grinder is a machine with the wheel slide (or wheel base) mounted at an acute angle with respect to the axis of the work. Shoulders and adjacent diameters, or faces that must be square with a bore, can be ground with great accuracy. The grinding lines on a face squared on a 45-deg. angular wheel slide are concentric circles, which is an advantage on certain types of bearing surfaces.

Fig. 1 shows a typical small, high production, 4 x 12 in. plain grinder.

Many of the plain grinders may be fitted with automatic sizing devices, automatic feeding and positioning cycles, power table traverse, air or hydraulically operated chucks or work-holders and other features for special uses (such as cam grinding attachments) or that make for semi-automatic operation. Machines to be employed as plunge cut grinders are frequently fitted with wheel spindle reciprocating mechanisms. Shoulder grinding attachments are built into machines if a great deal of this type of work is to be done.

Universal Grinders

(Sometimes called multipurpose grinders)

Universal grinders can grind either external (same as a plain grinder) or internal work; some small universal machines can be used for surface grinding. Within the range of a particular machine, external cylindrical, internal, and shoulder and face squaring jobs can be handled on universal grinders.

Work may be ground between centers or on an arbor, or held in a chuck or other suitable fixture. Universal grinders come equipped with a combination dead-live spindle headstock.

These machines are not built with automatic devices as they are generally used on small lot production where low cost precision rather than high output is needed.

A 16 x 36 in. universal grinder grinding an external surface on an aircraft radial engine part using the internal wheel is shown in Fig. 2.

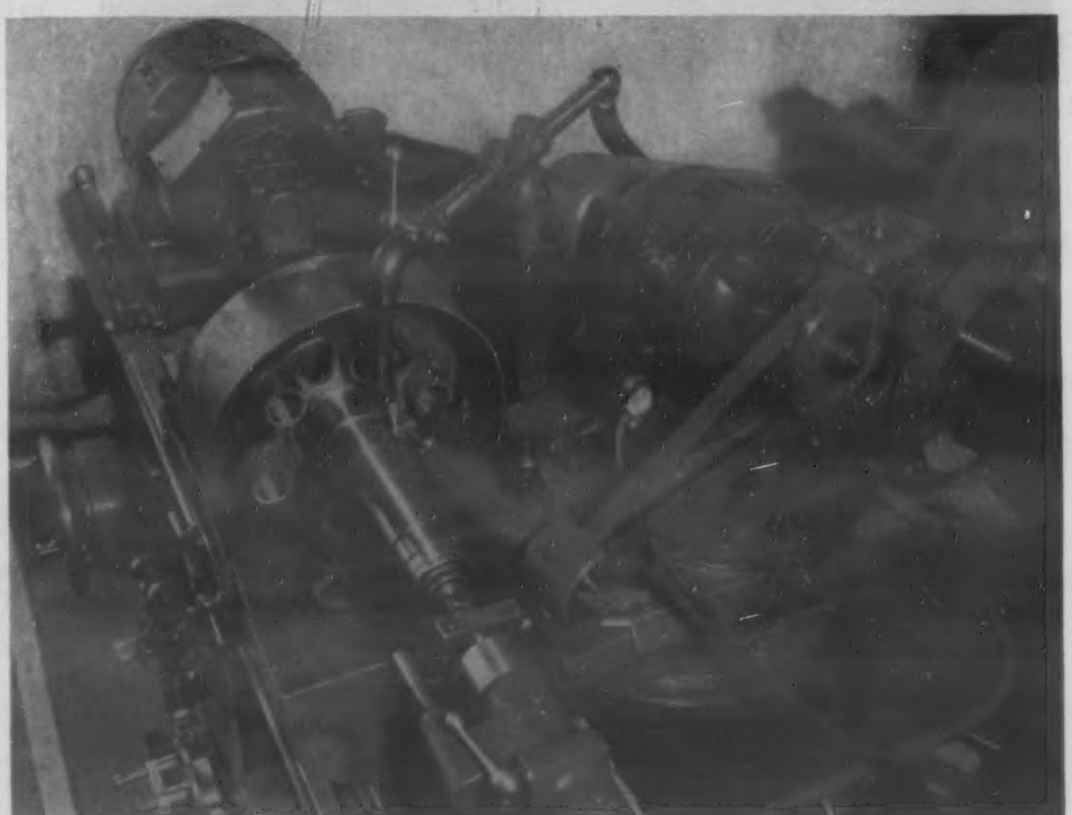


Fig. 2—A universal grinder (16 x 36) grinding the external diameter of an aircraft radial engine part with an internal wheel. (Courtesy: Norton Co.)

Fig. 3—A small horizontal spindle surface grinder used for accurate work. (Courtesy: H. J. Chamberland)

Fig. 4—A battery of 14-in. vertical spindle surface grinders in use in a large machine tool plant. (Courtesy: Pratt & Whitney Div., Niles, Bement, Pond Co.)

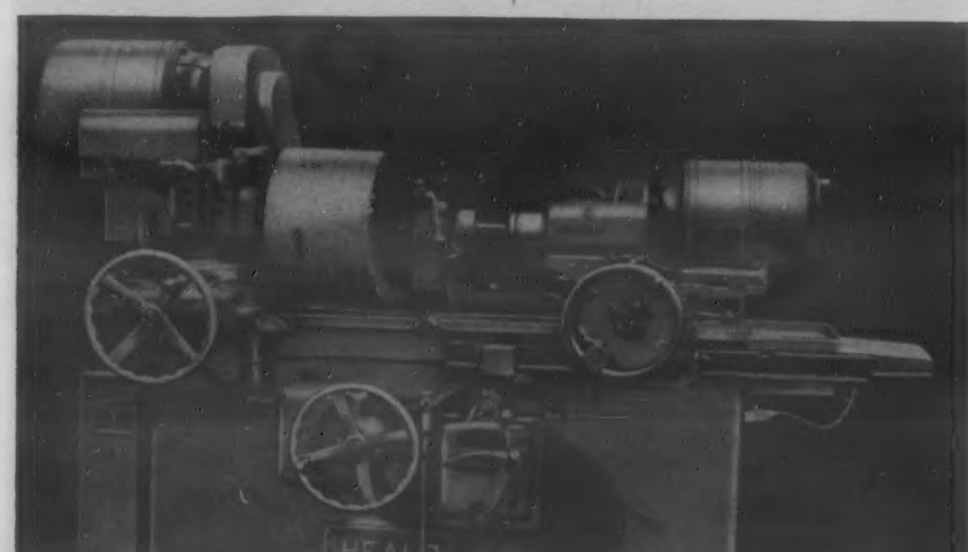


Fig. 5—Front view of an internal grinder. (Courtesy: Heald Machine Co.)

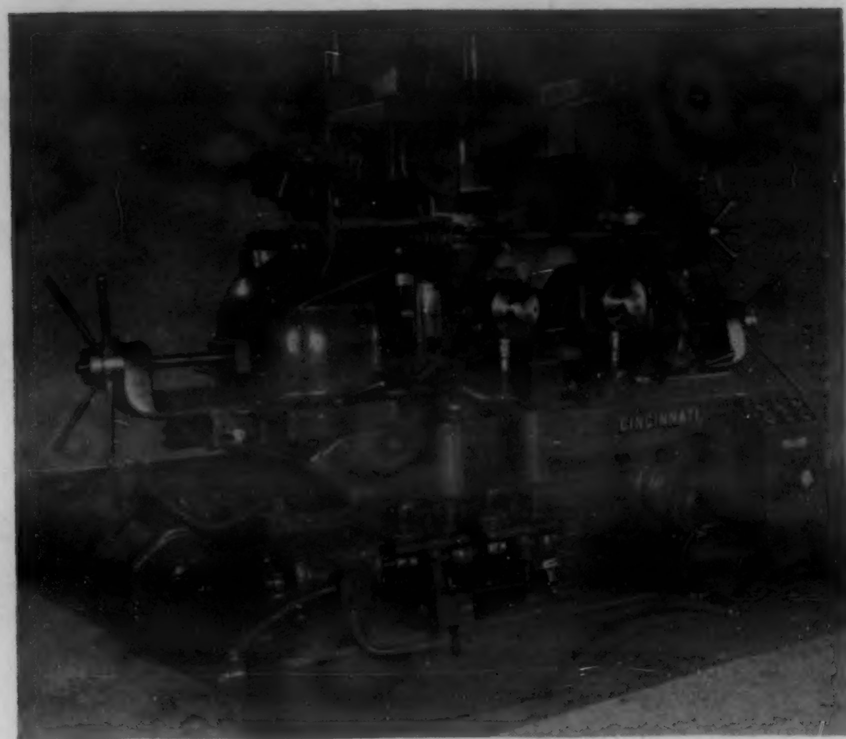


Fig. 6—A centerless grinder. (Courtesy: Cincinnati Milling & Grinding Machines, Inc.)

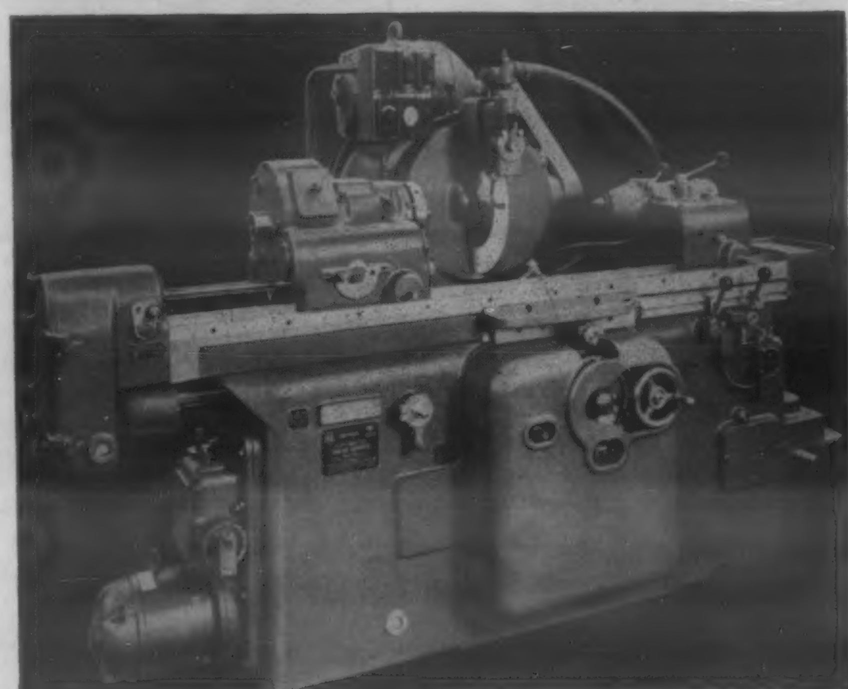


Fig. 7—Typical thread grinder (12 x 45) for external work. (Courtesy: Jones & Lamson Machine Co.)

rface Grinders

There are two main types of surface nders: rotary table (vertical spindle) and iprocating table (either horizontal or tical spindle) grinders. Each type has field of application (they are not mutu- exclusive) where its efficiency is atest. The surface grinding case studies t follow will illustrate some of these ds of usage.

While surface grinding is essentially for shing flat surfaces (plane surfaces at ious angles), many forms and shapes y be ground if the proper work-holders d/or formed wheels are used.

Power and manual feeds and traverses are ilable on many surface grinders as well automatic sizing devices for certain es.

A small horizontal spindle, reciprocating le surface grinder is shown in Fig. 3, and a battery of vertical spindle grinders are shown in Fig. 4. (See the case studies of surface grinding jobs for additional illustrations.)

Internal Grinders

Internal grinders are much the same as the universal machines except that they are for internal work only and often are semi-automatically operated (*i.e.,* they have way automatic feed and grinding cycles and automatic sizing mechanisms).

A typical, high precision internal grinder is shown in Fig. 5. Typical internal grinding jobs are included in the series of case studies that follows.

Centerless Grinders

Centerless grinders are a relatively newer type than either plain or surface grinders. Basically, there are two types of centerless grinders: external and internal. (Centerless thread grinders are discussed under "Thread Grinders").

Fig. 6 is a picture of one of the larger centerless grinders. For additional information on centerless machines, see the case-studies on centerless grinders.

Thread Grinders

Thread grinders are a very important and specialized type of grinder. By the use of a thread grinder, threads can be ground in hardened steel work with great rapidity and accuracy. The centerless type of thread grinder is a newcomer to the precision grinding field. The older types of thread grinders required that the work piece be supported either on centers or on an arbor.

Fig. 7 is a picture of a 12 x 45 in. precision thread grinder.

Fig. 8—A special type of grinder having two wheel heads and a fabricated steel base. This machine is plunge-cut grinding six diameters at the same time and removing 0.007 to 0.010 in. of stock. Production time is 50 sec. per shaft. (Courtesy: Fitchburg Grinding Machine Co.)

Fig. 9—Grinding the throws on an automotive crank shaft grinder. (Courtesy: Norton Co.)

Miscellaneous Special Types

This includes cam shaft, crank shaft, valve face, ball race and other special purpose grinders.

An important type of special purpose grinder is shown in Fig. 9; this is a machine for grinding the connecting rod bearing diameters of internal combustion engine crank shafts.

Through the use of specially designed grinding machines, the advantages of grinding can be applied to complicated or unusual high production items. Like all single purpose machines, their first cost is high and they often are either automatically or semi-automatically operated.

An example of a specialized grinding machine built around an unique type of head is illustrated in Fig. 8. The wheel head around which this machine is built is not fed by a feed screw as are most machines, but by controlling the hydraulic pressure on a leaf spring. Variations in the pressure on this spring cause it to bow or to flatten, depending upon whether the pressure is increased or decreased; if the spring flattens, its ends move horizontally feeding the grinding wheel into the work

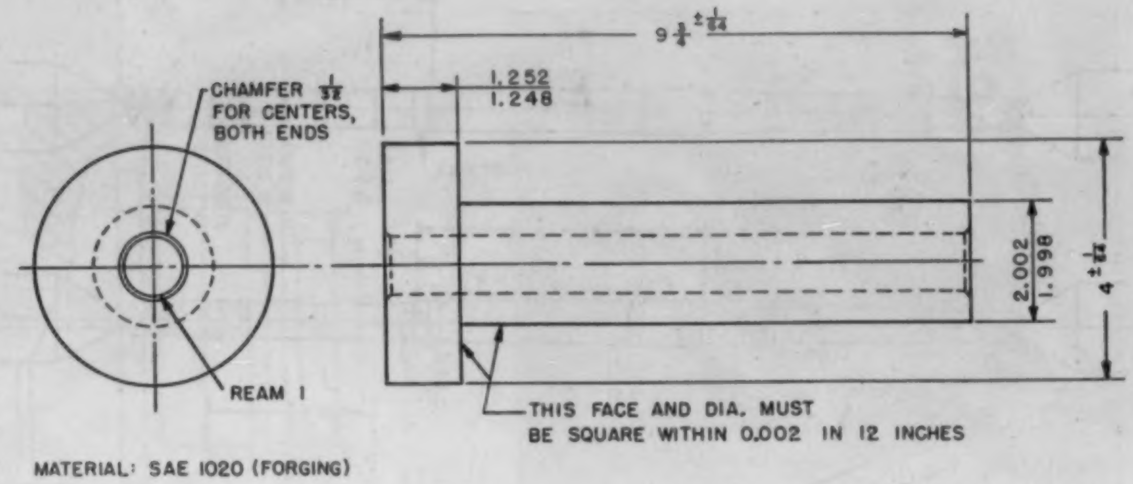


Fig. 10—Sketch of a spindle that can be finished in an engine lathe or a plain grinder.

nversely, bowing of the spring causes the heel to be retracted. Under conditions of rmal wear, there will be no backlash in is wheel-feed mechanism. By maintaining e ratio of vertical motion to horizontal heel travel large, approximately 250 to 1, e movement of the wheel head can be ntrolled very accurately. Both accuracy dimension and reproducibility are feaes of this type of mechanism.

The specifications for the double head inder shown in Fig. 8 are:

ormal swing	10 in.
ax. distance between centers	10 in.
ax. wheel dia. (with 2-in. wide wheel)	24 in.
ax. width of wheel (20-in. dia.)	4 in.
heel-head traverse (rapid)	0-5 in.
ax. amount of feed	1/16 in.
oor space required by machine	60 x 78 in.
et weight	5800 lb.

By virtue of interconnected control, the dependent wheel-heads on this machine may be semi-automatically operated to grind two angular surfaces at once and more than two in sequence. Because these wheel-heads are completely self-contained, they can be rearranged or remounted if an engineering change causes the operation (for which the machine was built) to be discontinued or substantially modified.

Another important type of specialized grinder is the gear grinder. The emphasis on hardened gears with errors in tooth form or spacing of 0.0002 in. or less has lead to the grinding of large number of precision spur and helical gears. Gear grinders may be divided into two classes: one employs a formed grinding wheel and operates on much the same principle as a form-milling machine. For use on this class of gear grinder, the gear tooth form must be generated exactly on the grinding wheel. The second class of gear grinder uses either one or two wheels. Each of these wheels represents one side of the flat-sided basic rack which is the origin of the involute spur or helical gear tooth system. If a single flat-sided wheel is used, only one side of the gear tooth can be ground at a time. However, if the wheel has both sides formed to duplicate the cone which is a development of the basic rack, one side each of two adjacent gear teeth can be ground at the same time. The gear grinder to be described below is of this latter type. Rough machined gears are mounted on centers for grinding. A different setting is used for spur and helical gears. A master gear, mounted on the end of the work spindle, one master rack and two indexing racks are required for each diametral pitch to be ground.

The importance of grinding as a precision process in both production and job-lot shops is best illustrated by reporting in some detail a series of grinding operations. These case studies are drawn from a number of different factories, and they were selected to show the individual capabilities of the various standard types of grinding machines.

Case Studies: Plain Grinders

A job that shows how cylindrical grinding can compete with an engine lathe for finishing soft steel parts is sketched in Fig. 10. This spindle (a SAE 1020 forging) is roughed out on a lathe leaving 1/64-in. of stock on all surfaces for finishing except the 9¾-in. dimension, which is to size. The 1-in. hole is reamed to size and both ends of the ID are chamfered for centers. If one rough spindle is finished in an engine lathe and another on a 10-in. plain grinder, one shop calculates the time as follows (time is expressed in standard hours):

	Set Up	Per Piece Time
Time to finish spindle on lathe	0.23	0.16
Time to finish spindle on 10-in. plain grinder	0.20	0.14

This, then, demonstrates that grinding can compete successfully with the lathe as a means of finishing unhardened steel, especially where fine finishes or close tolerances are involved.

A series of four operations, performed

Specifications of a Typical Gear Grinder

Capacity	Single Wheel Gear Grinder	2-Wheel Gear Grinder
Max. OD of gear to be ground	10-11/16 in.	10-11/16 in.
Root dia., min., using small master gear spindle	13/16 in.	13/16 in.
using regular master gear spindle	2 in.	2 in.
min. for 5¼-in. tooth length gears using plain bearing tailstock spindle	13/16 in.	—
min. for 5¼-in. tooth length gears using ball bearing tailstock	2¾ in.	—
Diametral pitch range	3 to 16	3 to 16
Pressure angle range	13 to 30 deg.	12 to 25 deg.
Helix angle (right or left)	up to 45 deg. incl.	up to 45 deg. incl.
No. of teeth, nominal min.	7	7
Width of teeth, max., with 13¾-in. long arbor, ball bearing tailstock	5¼ in.	1¼ in.
with 14¼-in. long arbor, plain bearing tailstock (13/16 to 2 in. root dia.)	5¼ in.	1¼ in.
with 14¼-in. long arbor, plain bearing tailstock (2 in. and larger root dia.)	5¾ in.	1¼ in.
Max. length between centers—plain bearing tailstock	14¼ in.	14¼ in.
Max. length between centers—ball bearing tailstock	13¾ in.	13¾ in.
Wheel dia.	(1) 12 in.	(2) 20 in.
Floor space required by grinder	97 x 75 in.	97 x 75 in.
Weight (net with regular equipment)	7800 lb.	9900 lb.

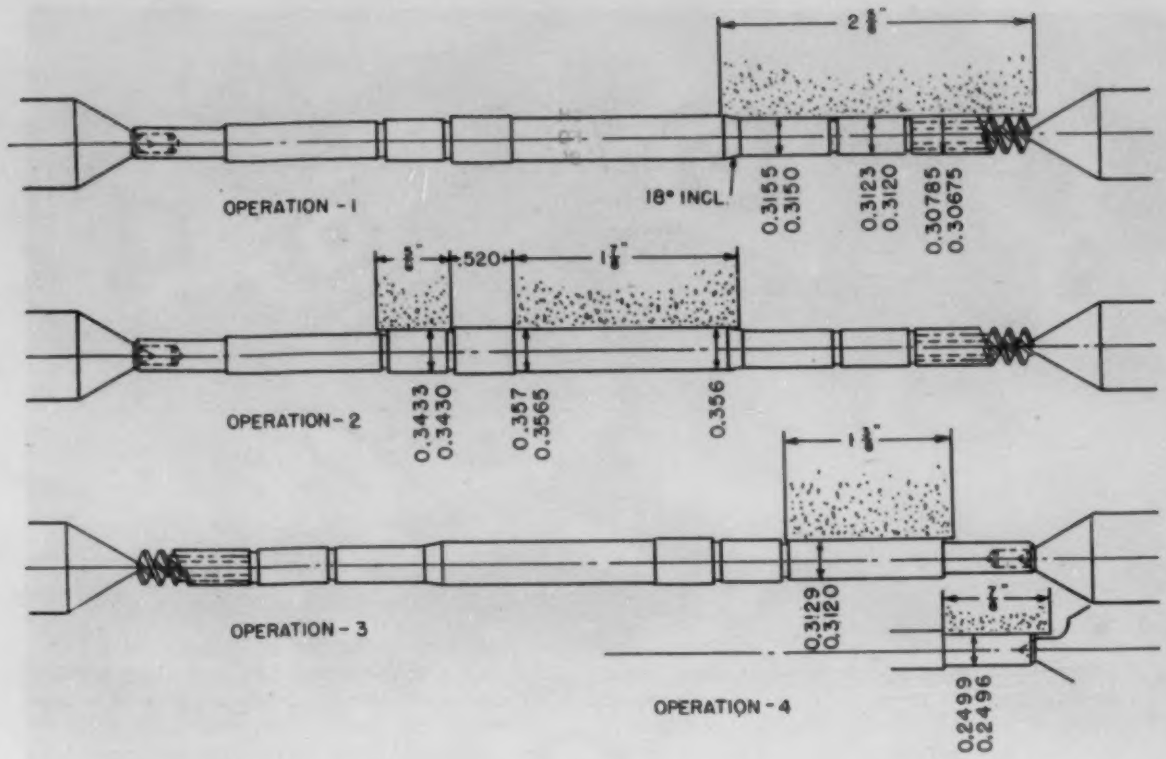


Fig. 11 — A series of plain grinding operations performed on a 4 x 12 in. cylindrical grinder. (Courtesy: Landis Tool Co.)

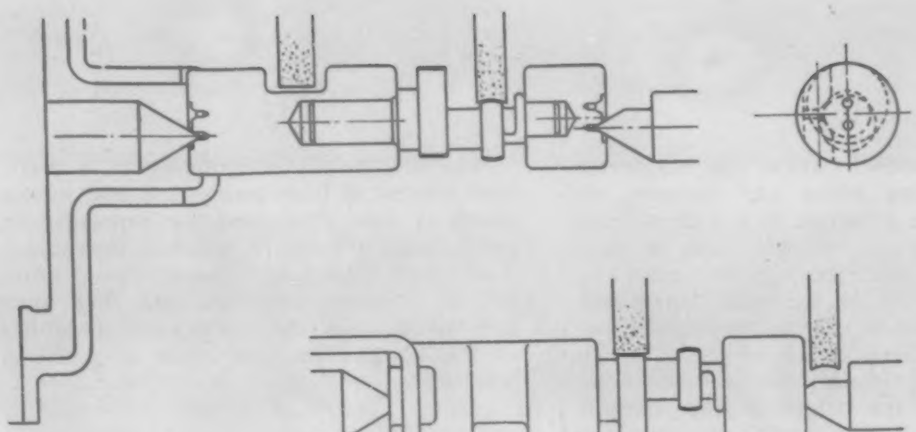


Fig. 12—This eccentric shaft requires a pair of eccentric female centers for holding during grinding on a 4 x 12 in. plain grinder. (Courtesy: Landis Tool Co.)

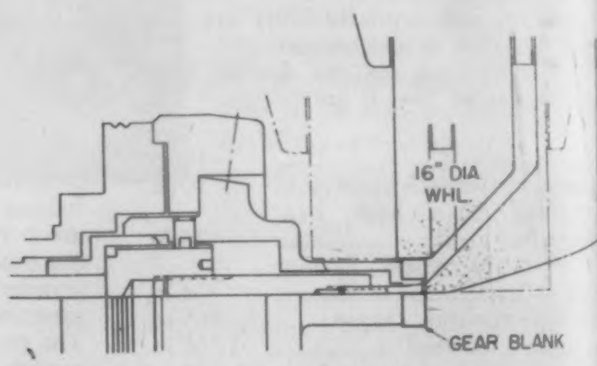


Fig. 13—Set up for grinding the OD face of a ge[ar] blank in one plunge-cut operation using two grind[ing] wheels on the same wheel spindle. (Courtesy: Land[is] Tool Co.)

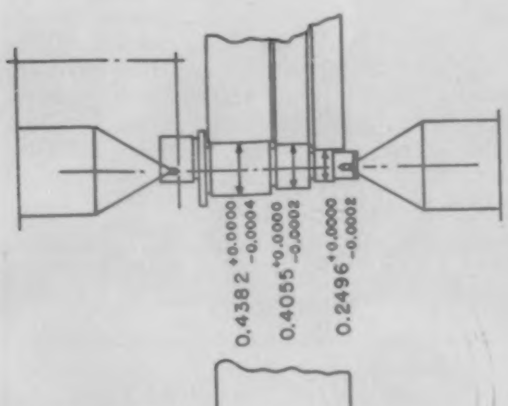
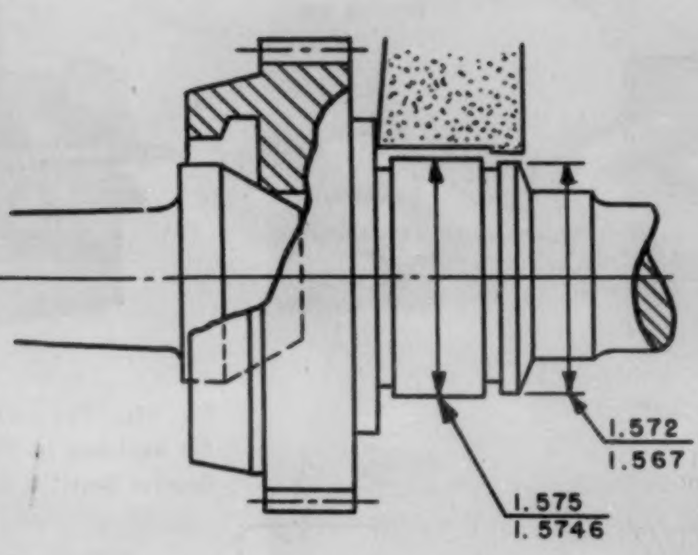


Fig. 14—Sketch of the crushing tool (lower) for crush-forming the grinding wheel and, in the upper sketch, the part that is plunge-cut with the formed wheel. (Courtesy: Landis Tool Co.)

on four 4 x 12 plain grinders in successi[on] are sketched in Fig. 11. Operation 1 [is] performed on a machine having a 2⅝-in. wide wheel formed to grind the 0.3072[5] [to] 0.30675, 0.3123 to 0.3120, 0.3155 [to] 0.3150 diameters and the 18-deg. includ[ed] angle taper all in one plunge cut. T[he] second machine then receives this shaft [for] the grinding of the 0.3433 to 0.34[30] diameters. These are ground in a plun[ge]-cut operation and the machine has t[wo] grinding wheels (one ⅜ and the oth[er] 1⅞-in. wide), on its wheel spindle. [In] the third operation, the shaft is revers[ed] (the driving dog is placed on the oppo[site] end) and the 0.3123 to 0.3120 in. diame[ter]



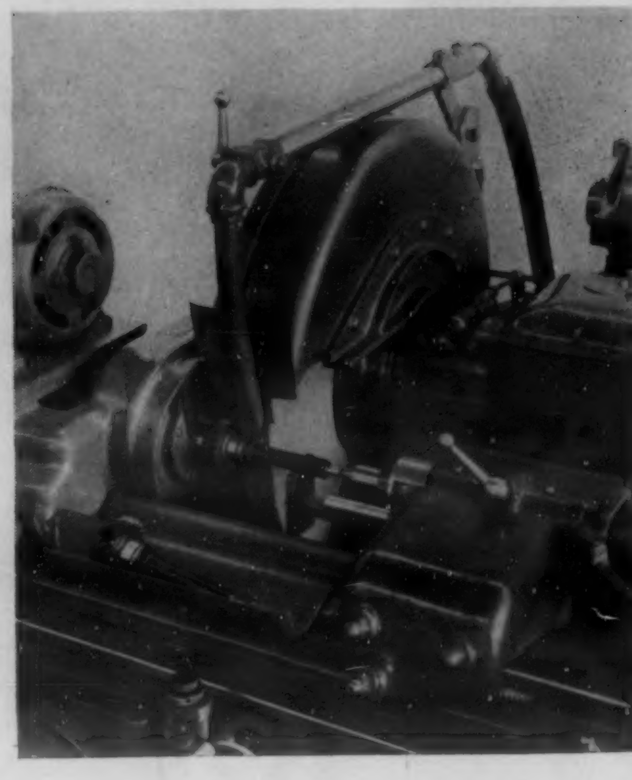


Fig. 15—Sketch of ground portion of work-piece and photograph of the grinding set up for finishing a hardened steel transmission clutch gear on a 10 x 18 semi-automatic plain grinder. (Courtesy: Norton Co.)

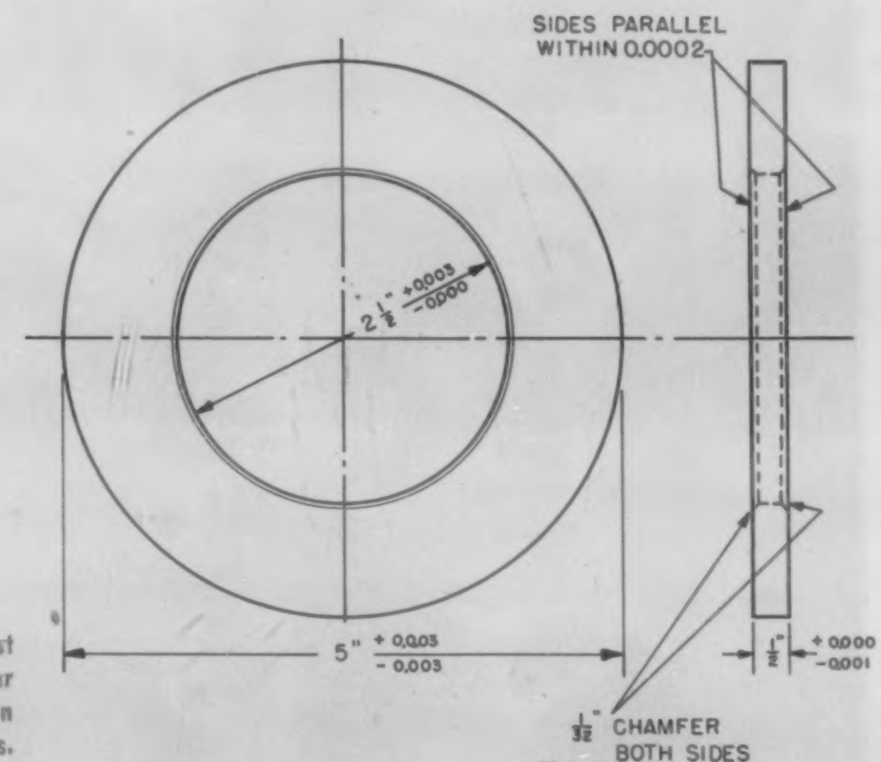


Fig. 16 — Sketch of cast iron slitter knife spacer that is surface ground on both faces to close limits.

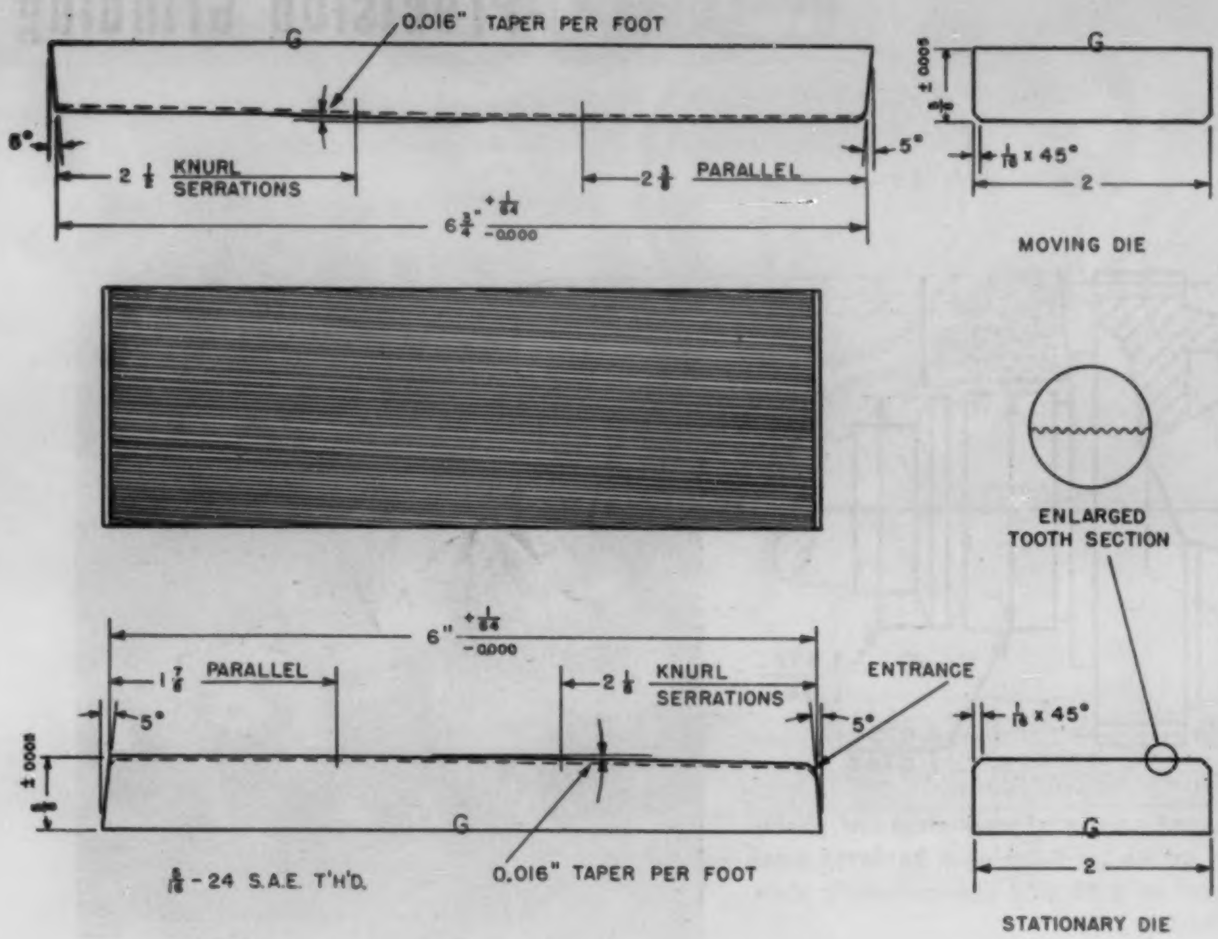
is finished in one plunge cut) with a 1⅜-in. wide wheel. The final, or fourth, operation is to grind the 0.2499 to 0.2496 diameter using a ⅞-in. wide wheel. By using a semi-automatic cycle (hand loading, automatic feed and grinding cycle) and an accurate automatic sizing mechanism, these opeartions can be completed almost as rapidly as a man can load and unload the grinders.

Some other jobs on 4-in. machines are sketched in the following figures. Fig. 12 shows an eccentric shaft held by two eccentric female centers. First, the crowned diameter is ground, then the table is indexed into the proper position so that the straight diameter can be ground. This is another example of the usefulness of a double wheel set up. Another double wheel set-up for grinding the face and OD of a gear blank is shown in Fig. 13. The work-piece is held in a drawn-in collet in a live spindle headstock. The 16-in. dia. wheel grinds the OD while the lip of the cup-shaped wheel is squaring the face. The crushing tool used to form a 1⅛-in. wide wheel, and the job this crushed wheel does are indicated in Fig. 14.

The grinding set-up used for grinding two diameters and a shoulder of a hardened steel transmission clutch gear is shown in Fig. 15. A formed wheel is used so that the three surfaces can be ground in one plunge cut. During this operation 0.020 to 0.028 in. of steel is removed from the diameter and the limits are given in the sketch. Using a semi-automatic machine (manually loaded and started, and automatically ground to size, then manually unloaded) this 10-in. machine will turn out 150 to 160 of these parts per hour.

Case Studies: Surface Grinders

The grinding of the parallel sides of slitter knife spacers (Fig. 16) is an excellent example of the precision use of a surface grinder. When these spacers come to



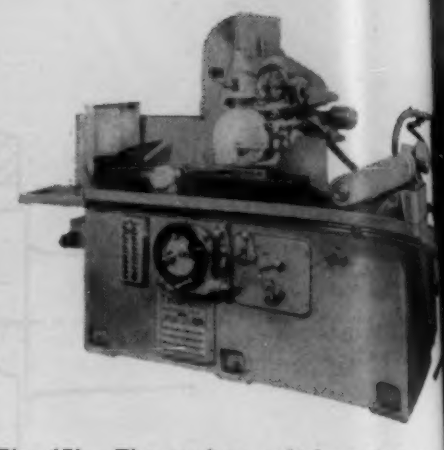


Fig. 17b—The surface grinder set up to die sketched in Fig. 17a. (Courtesy: The Grinder Co.)

Fig. 17a—Drawing of a special alloy steel roll thread die that is formed by grinding on a precision surface grinder.

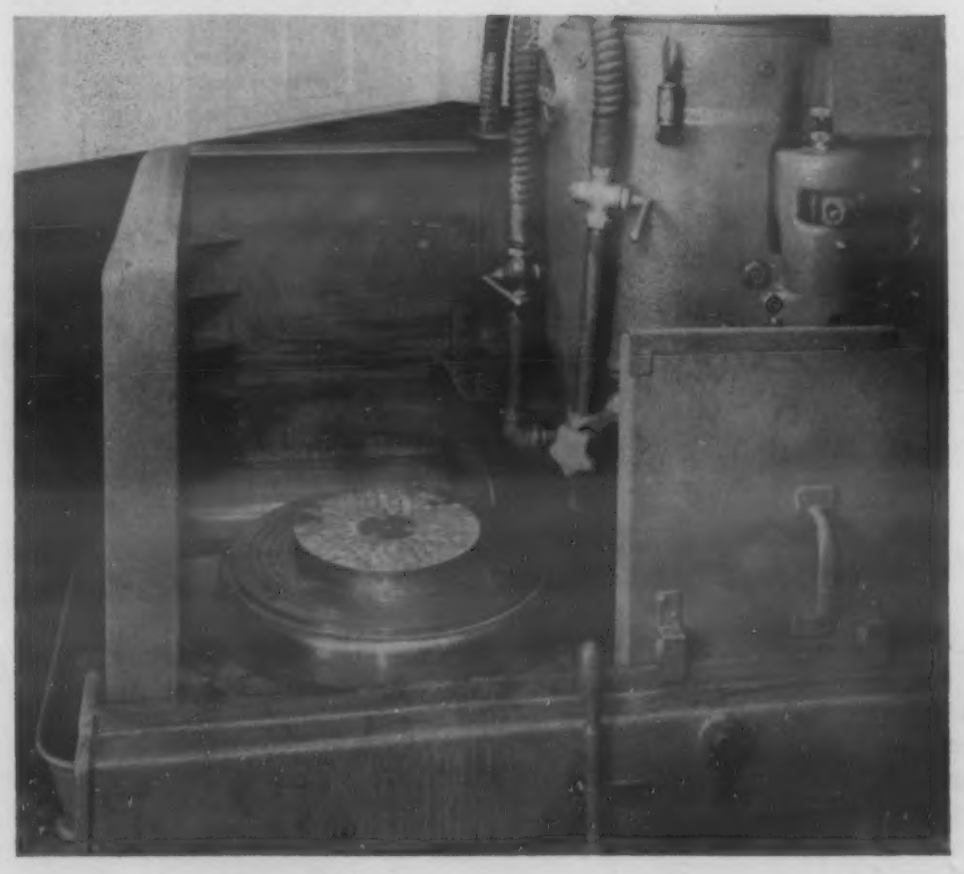


Fig. 18—Rotary table surface grinder set up for grinding quartz crystals for radio frequency generators. (Courtesy: Blanchard Machine Co.)

the grinding operation, they are 0.015 to 0.020 in. oversize (thick). The shop making these spacers calculates the standard time for this surface grinding operation (removing 0.015 to 0.020-in. stock from the thickness and keeping the ½-in. dimension within the limits, standard to 0.001 undersize, and the sides parallel within 0.0002 in.) to be: set up, 0.34; and per piece time, 0.05 standard hours.

Form grinding on a surface grinder is illustrated in Figs. 17a and 17b. The pair of roll thread dies for rolling 5/16-in. dia., 24 threads per in. screws are shown in Fig. 17a. These are made of hardened (Rc 62 to 65) high speed steel. The surface grinder set up for grinding the thread forms into the die blanks is shown in Fig. 17b. The blank is mounted on a permanent magnet chuck and set at the proper angle with a sine bar. (The helix angle is measured from the side of the die.) The two cams on the front of the grinder are set so that the radius, taper and straight sections of the die is generated in a single pass of the wheel at full depth at a table traverse rate of approximately 2 in. per min. A pair of these dies can be ground in approximately 7 min. The set-up time on this job is approximately ½ hr.

In a rotary table surface grinder set-up for grinding steel rocker arm forgings, a total of 0.005 in. of stock is removed; the faces of the rocker arms must be parallel within 0.0005 in. With this set-up, the production is approximately 235 pieces per hr.

In a rotary surface grinder, quartz crystals for radio frequency generators are ground rapidly and accurately. The set-up is illustrated in Fig. 18. These crystals are received in the rough sawed condition and

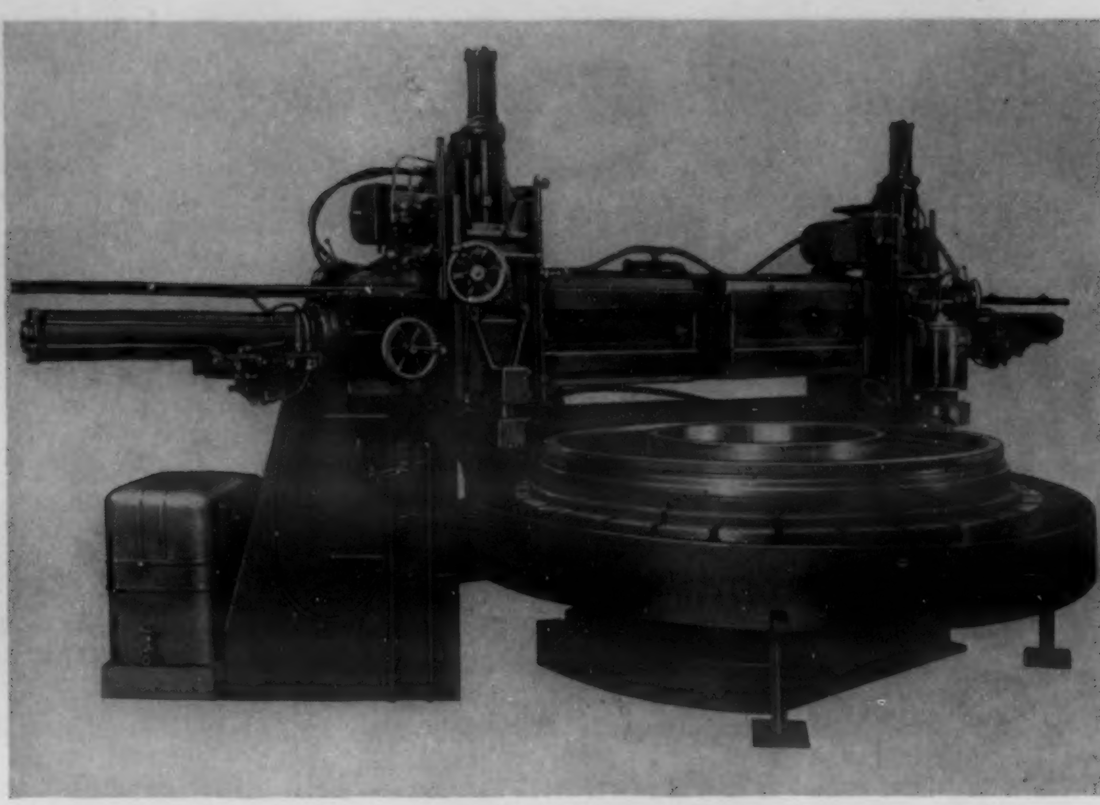


Fig. 19—A 100-in. rotary table precision grinder for finishing naval ordnance parts. (Courtesy: Kaydon Engineering Corp.)

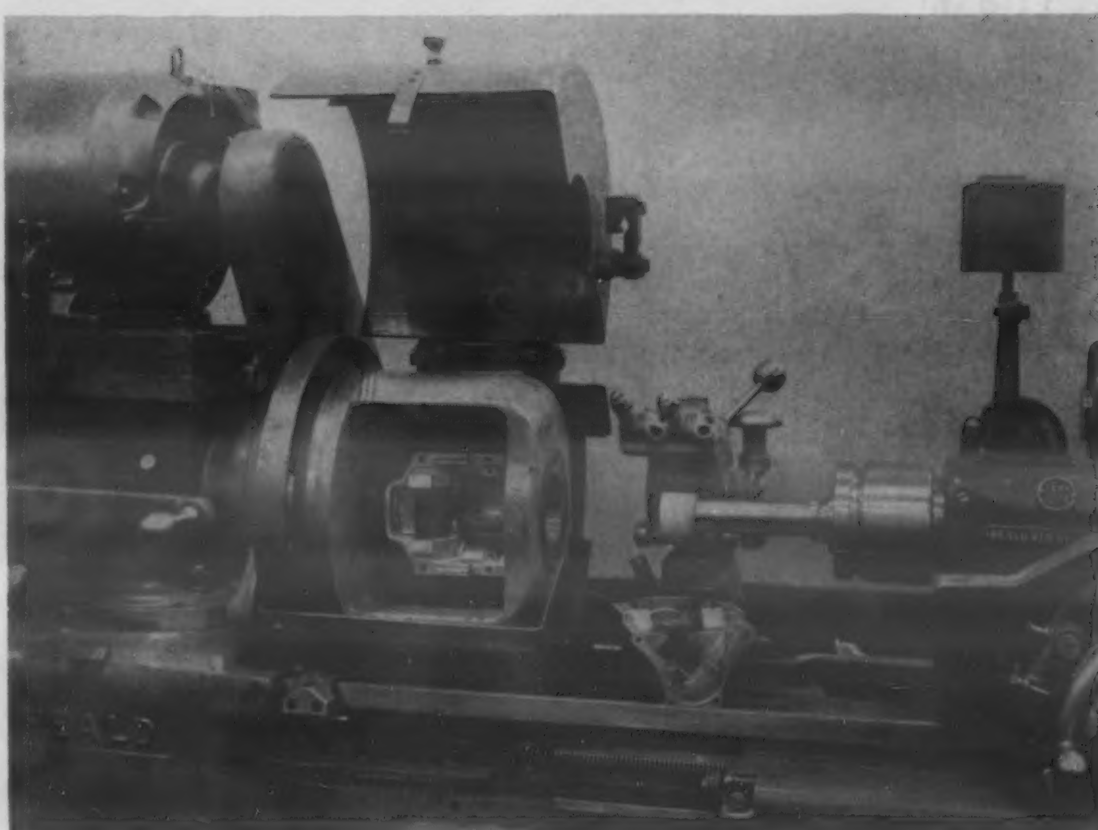


Fig. 20—Internal grinding set up for finishing the bore in an aircraft magneto housing. (Courtesy: Heald Machine Co.)

0.015-in. stock is removed from each of two opposite sides; the tolerance is plus or minus 0.0005 in. 1000 pieces can be ground per hr.

Cast iron shaper tables are ground on a rotary surface grinder. These castings are ground from the rough, approximately 1/8 in. of stock being removed from each side in the process; the time is approximately 1 hr. and 35 min., and the completed tables must be square within 0.0015 in. in 16 in. Each casting is 15½ x 15½ x 16 in.

An unusual type of surface grinder that resembles a large boring mill is shown in Fig. 19. This double head machine was developed for the precision grinding of large Navy gun mount parts. The major dimensions of this machine are: 21 ft. long x 10 ft. 7 in. wide, it extends 8 ft. 11 in. above and 5 ft. 7 in. below the floor line. The 100-in. table will accommodate, by means of suitable fixtures, work-pieces up to about 120 in. in dia.

Gun mount bearings 64½ and 121 in. in dia. can be ground on this machine to standard tolerances of 0.002 in. on the OD and a 0.001 in. parallelism. Also, the base mounts (72 in. in dia.) for large guns can be finish ground with an accuracy of 0.0005 in. for flatness, roundness, squareness and concentricity.

Case Study—Internal Grinder

A precision internal grinding job is illustrated in Fig. 20. In this picture, the side-loading balloon work-holder which holds and locates the work-piece is clearly visible and the work-piece (an aircraft magneto housing made of laminated steel) can be seen in position for grinding. The ID of this housing is ground to 2.0000 to 2.0015

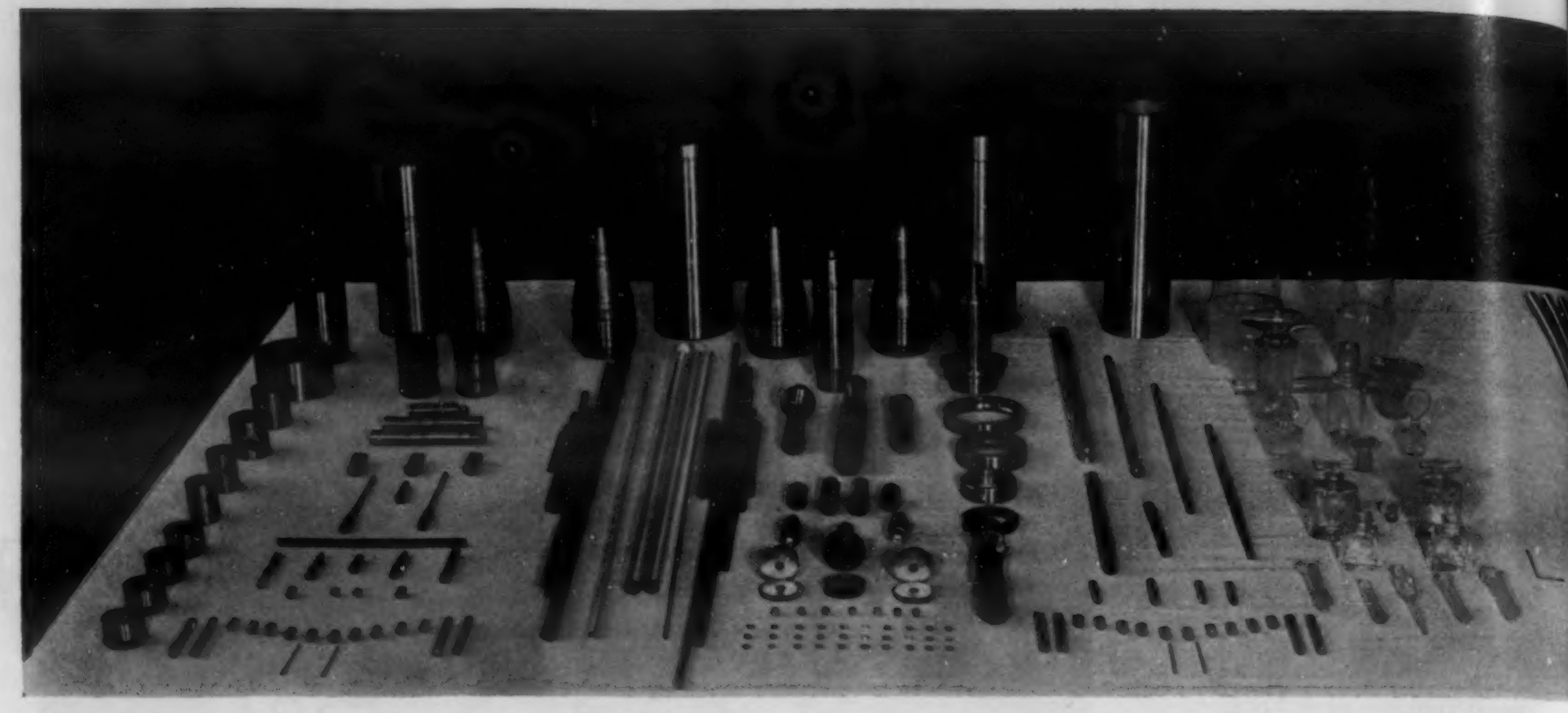


Fig. 21—A variety of centerless ground parts; steel, hard rubber, glass, powder metal parts and nonferrous items are included. (Courtesy: Landis Tool Co.)

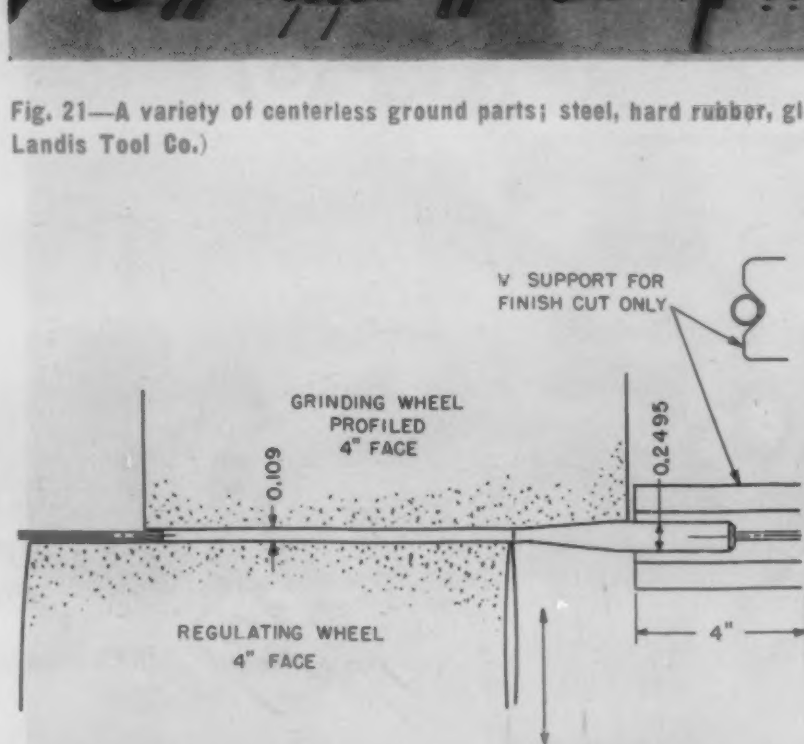


Fig. 22—Sketch of three diameter centerless ground steel part. (Courtesy: Landis Tool Co.)

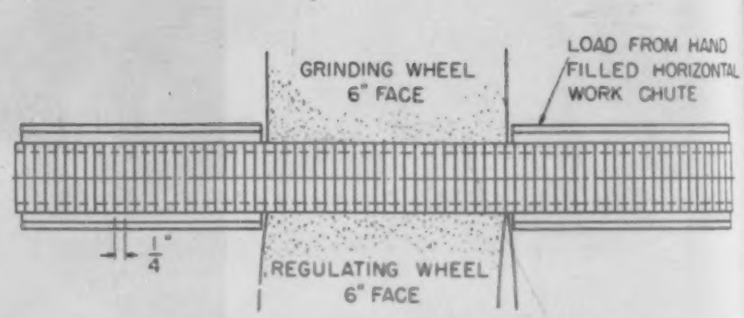


Fig. 23—High production through-feed centerless grinding job (cast iron piston rings). (Courtesy: Landis Tool Co.)

in. dia. with the removal of 0.010 to 0.012 in. of stock.

Case Studies: Centerless Grinders

An unusual array of centerless ground items is shown in Fig. 21. The dark rods on either side of the colorless plastic rods (left center) are hard rubber (tubing and solid rods). In the center foreground area the series of silver plated powder metal contacts ranges in size from about ¼ in. in dia. to 2 in. A wide variety of centerless-ground glass parts occupies the right hand portion of the illustration. These different shapes and materials indicate the versatility of centerless grinding. Through-feed, end-feed and in-feed jobs are all represented.

A burring tool that has two straight diameters and a taper is shown in Fig. 22. These are first through-ground to remove 0.010-in. stock at a rate of 600 per hr. Following this, the work-pieces are plunge-cut ground (or end-fed) to rough form the taper and 0.109 in. dia.; 90 pieces per hr. is the production rate for this roughing operation. Finish grinding the taper and small straight diameter follows at a rate of 450 per hr.

A high production centerless job, grinding the OD's of cast iron piston rings is sketched in Fig. 23. The rough castings have their sides machined to ¼-in. dimension and then are hand loaded into a through-feed work chute. In the roughing operation, 0.060 in. of stock is removed from the OD; after roughing the rings must be within 0.0005 in. in roundness and straightness. In the finish operation, 0.001-in. stock is removed and the roundness and straightness limits are 0.0002 in. A total of 7 cuts or passes are required to grind these rings from the rough. The rate of production is 6000 per hr. per cut for roughing and 5000 per hr. per cut for finishing.

An example of internal centerless grinding illustrates the accuracy of this type of machine. Fig. 24 shows the feeding chute and work-piece in position in an internal centerless grinder. The parts to be ground are aircraft engine piston pins and they are so long (5.598 in.) that grinding the entire length of the ID from one end is not efficient. Because accurate relocation of the work-piece is possible, these pins have each end ground separately (they are reversed between operations). The ends of these pins are ground to 1.1245 in. ID x 1 in. long; both ID's are concentric with

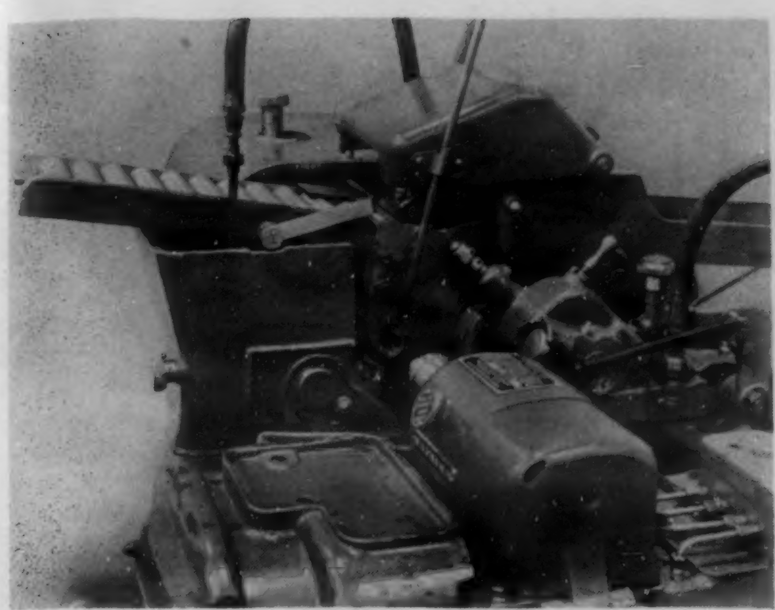


Fig. 24—Set up for semi-automatic internal centerless grinding of aircraft engine piston pins. (Courtesy: Heald Machine Co.)

Fig. 25—Armature shaft showing plunge-ground worm threads. (Courtesy: The Sheffield Corp.)

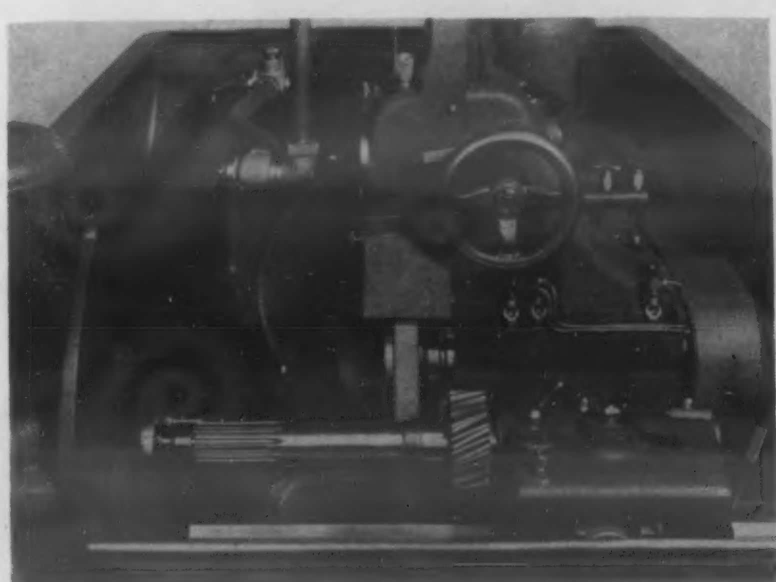


Fig. 26—An automotive transmission part in place in a precision thread grinder after having its 1⅞-16 thread ground. Note the formed (crush-formed) wheel. (Courtesy: The Sheffield Corp.)

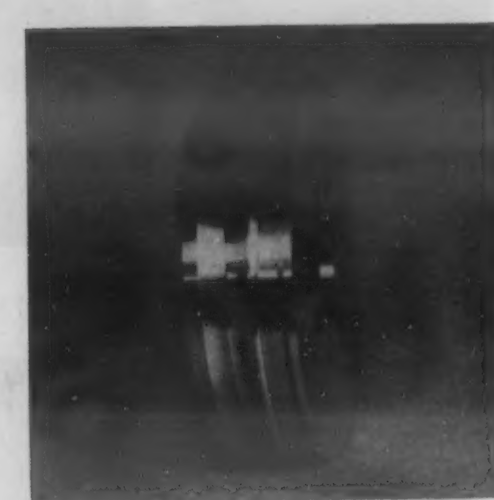


Fig. 27a—Photograph of hardened high-speed steel circular form tool that is quickly and accurately ground using a crush-formed wheel.

the OD within plus or minus 0.00025 in., and in almost perfect alignment.

Case Studies: Thread Grinders

An armature shaft that has a reciprocating drive worm on one end is shown in Fig. 25. This worm is plunge ground from the solid in a revolution and a half of the work-piece. The worm has an OD of 0.312 in., 38 D.P., and a 14½-deg. pressure angle; the tops of the threads are modified with a 0.046-in. radius. The previous machining sequence produced 75 pieces per hr., and additional time for removal of burrs was needed. By using a crush-formed wheel in a precision thread grinder, the production rate was increased to 120 pieces per hr. and no additional was needed for deburring as the first imperfect thread is removed in the one operation. The dressing roll (for forming the wheel) used in this operation needs resharpening every 5000 pieces.

Fig. 26 shows the set-up for plunge grinding a 1⅞-16 x ⅜ long class 3 thread on an automotive transmission part. The thread is ground from the solid in 1½ revolutions of the work-piece; the time is approximately 34 sec. The formed (ribbed) wheel is clearly visible in the photograph.

The savings realized from using crush-formed wheels for grinding threads and similar forms is well illustrated by the following examples. A circular form tool, shown in Figs. 27a and 27b, has a somewhat complicated contour and is made of hardened high-speed steel. The previous method of manufacture involved rough machining, hardening, and then grinding. This grind-

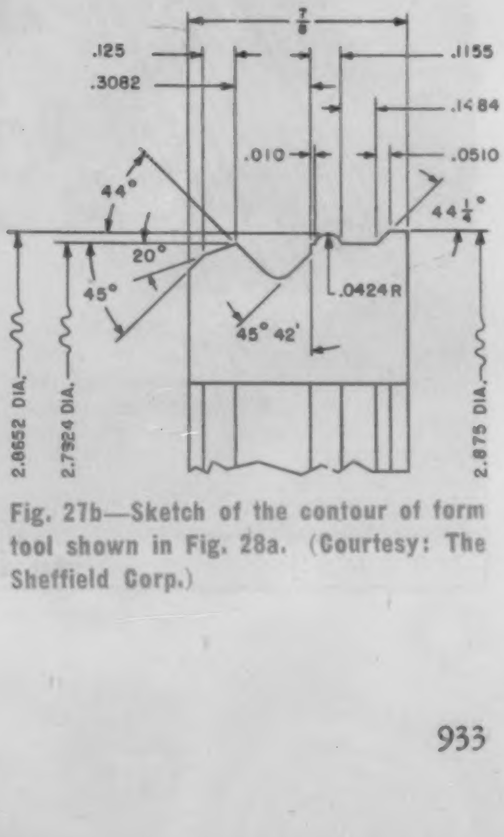


Fig. 27b—Sketch of the contour of form tool shown in Fig. 28a. (Courtesy: The Sheffield Corp.)

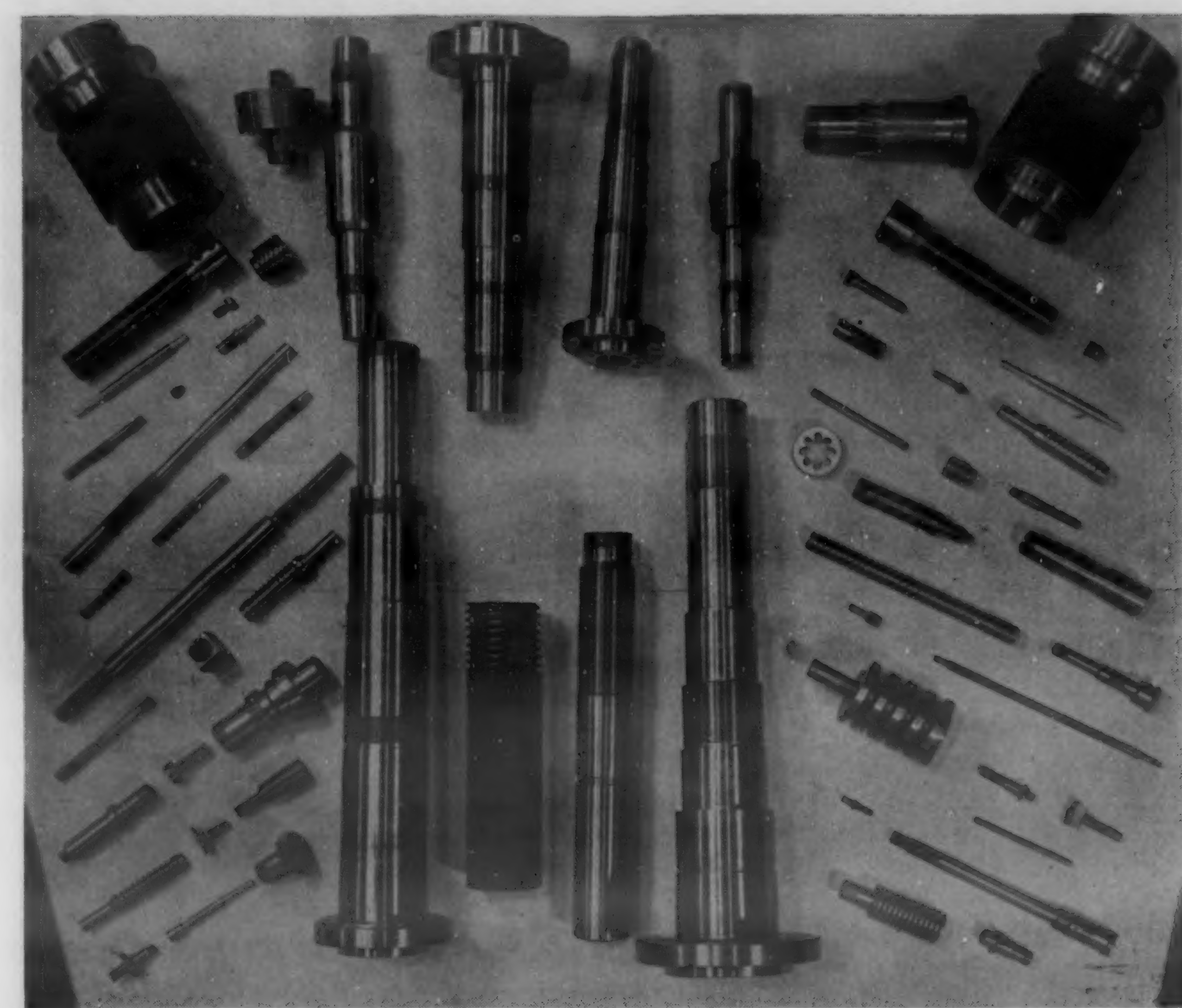


Fig. 28 — Examples of ground threads. (Note the examples of internal ground threads included). (Courtesy: Jones & Lamson Corp.)

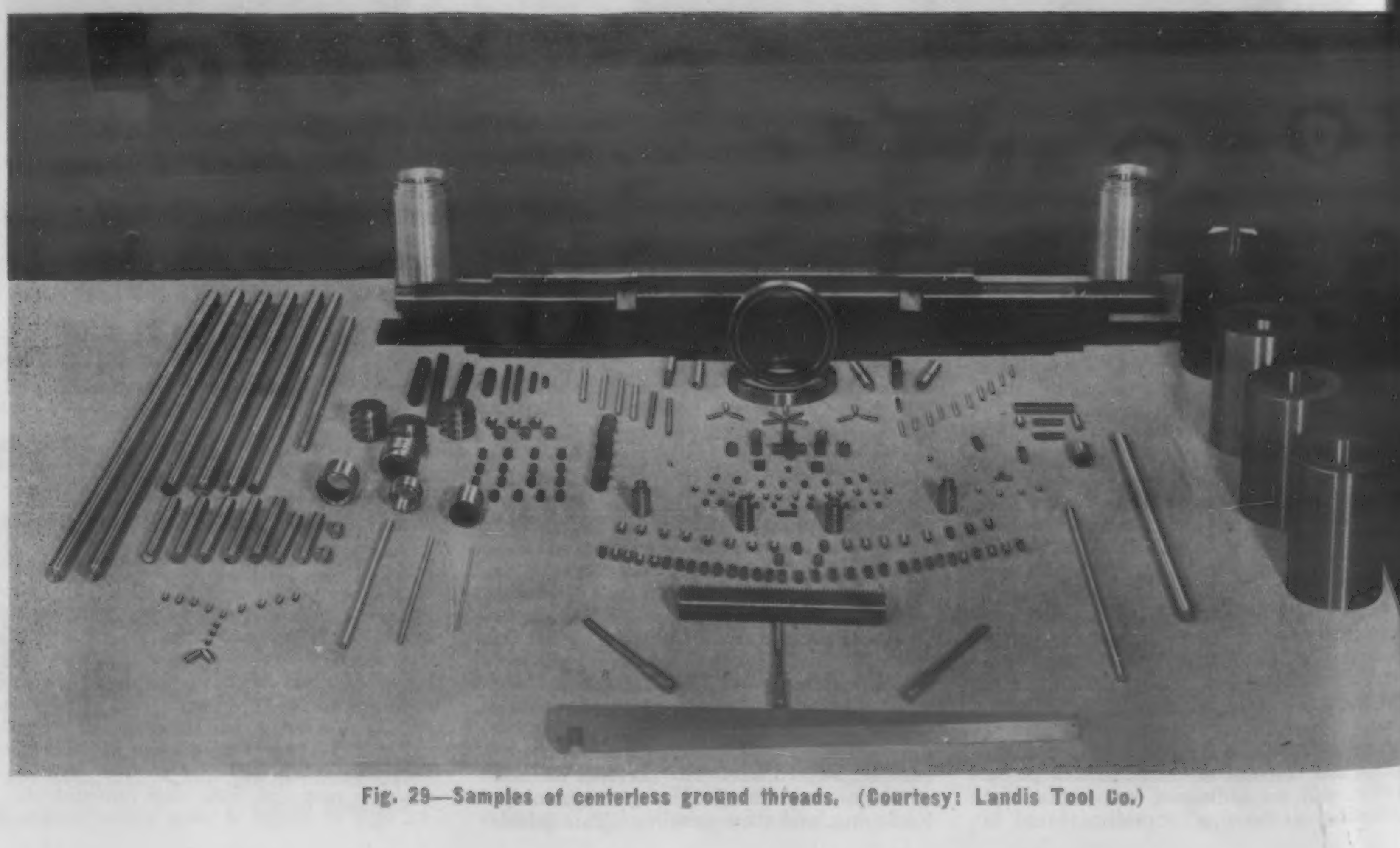


Fig. 29—Samples of centerless ground threads. (Courtesy: Landis Tool Co.)

Fig. 30 — Circular steel rack that is plunge-ground on a centerless thread grinder. (Courtesy: Landis Tool Co.)

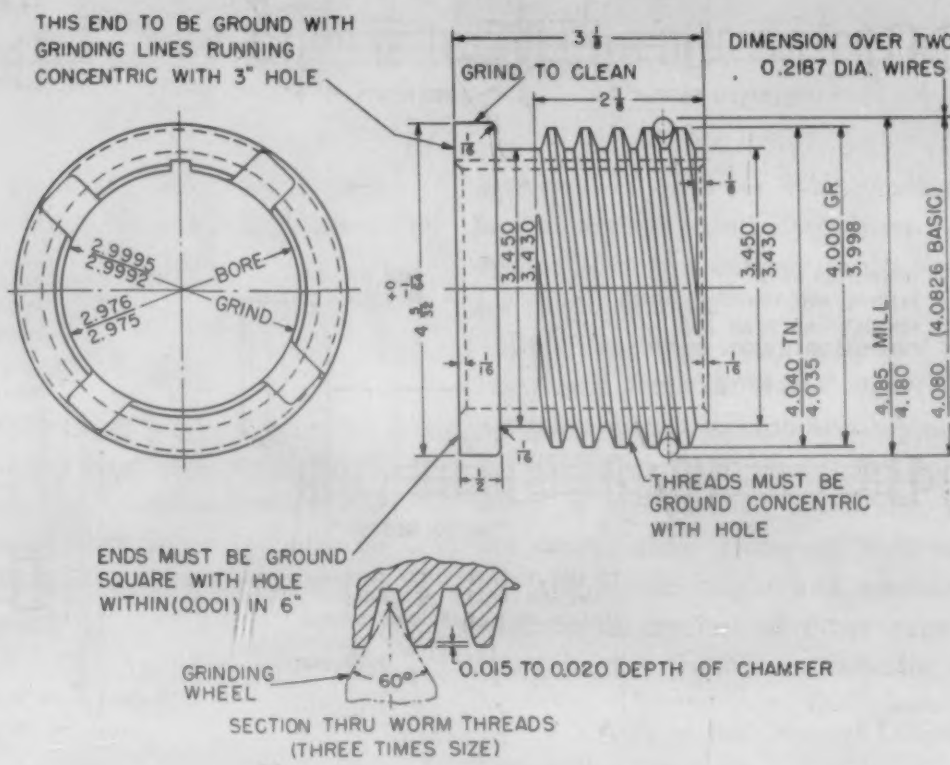


Fig. 31—Worm sleeve of high tensile steel finished by grinding.

ing operation required 4½ to 5 hr. per form tool when made in lots of 15 to 30. Using a crush-formed wheel, these form tools can be ground from the solid in less than 15 min. each; if the form tools are rough machined, they can be finished ground with a crushed wheel in approximately 4 min. The time required to make a crusher roll for crush-forming the wheel is about the same as for making one form tool by the previously used method; therefore, savings are only possible if the lot quantities are 2 or more pieces. In larger lots, the savings are very large.

Examples of the range of jobs possible in standard thread grinders may be seen in Fig. 28.

Parts that have been threaded in a centerless thread grinder are shown in Fig. 29. The circular racks in the central foreground (just behind the helix angle adjustment bar) are a good example of this type of grinding. A close-up of one of these is shown in Fig. 30; this part is ¼-in. in dia. and the rack teeth are ground from the solid in a single plunge cut (using a formed wheel) in 1¼ min. The resulting accuracy is with 0.0001 in 1-in. length.

The production volume possible with a centerless thread grinder is illustrated by considering the time required to grind ¼-20 screws from the solid. An economical rate has been found to be 30 to 35 in. of thread ground per min.; or, if ½-in. long blanks are fed into the centerless thread grinder, 60 or 70 completed screws would be produced.

Errors are very small in screws ground by this method: lead errors may be less than 0.0005-in. per in., sometimes as low as 0.0001-in. per in.

Case Studies—Concluded

In conclusion, two case studies are presented that involve more than one grinding operation on more than one type of grinding machine.

The various grinding operations performed (and the standard time for each) on the worm sleeve shown in Fig. 31 are tabulated below.

Description of Operation	Machine Used	Standard Time, Hr. Set Up	Standard Time, Hr. Per Pc.
Rough grind OD and outside face of flange, 4.000 in. dia. and small end	10 x 18 plain grinder with a 45 deg. angular wheel slide	0.25	0.16
Rough and finish grind ID	Internal grinder	0.61	0.48
Finish grind OD of flange and 4.000-in. dia.	10 x 18 plain grinder	0.20	0.11
Grind threads	Thread grinder	0.94	0.86
Grind chamfers on threads	Thread grinder	0.94	0.13

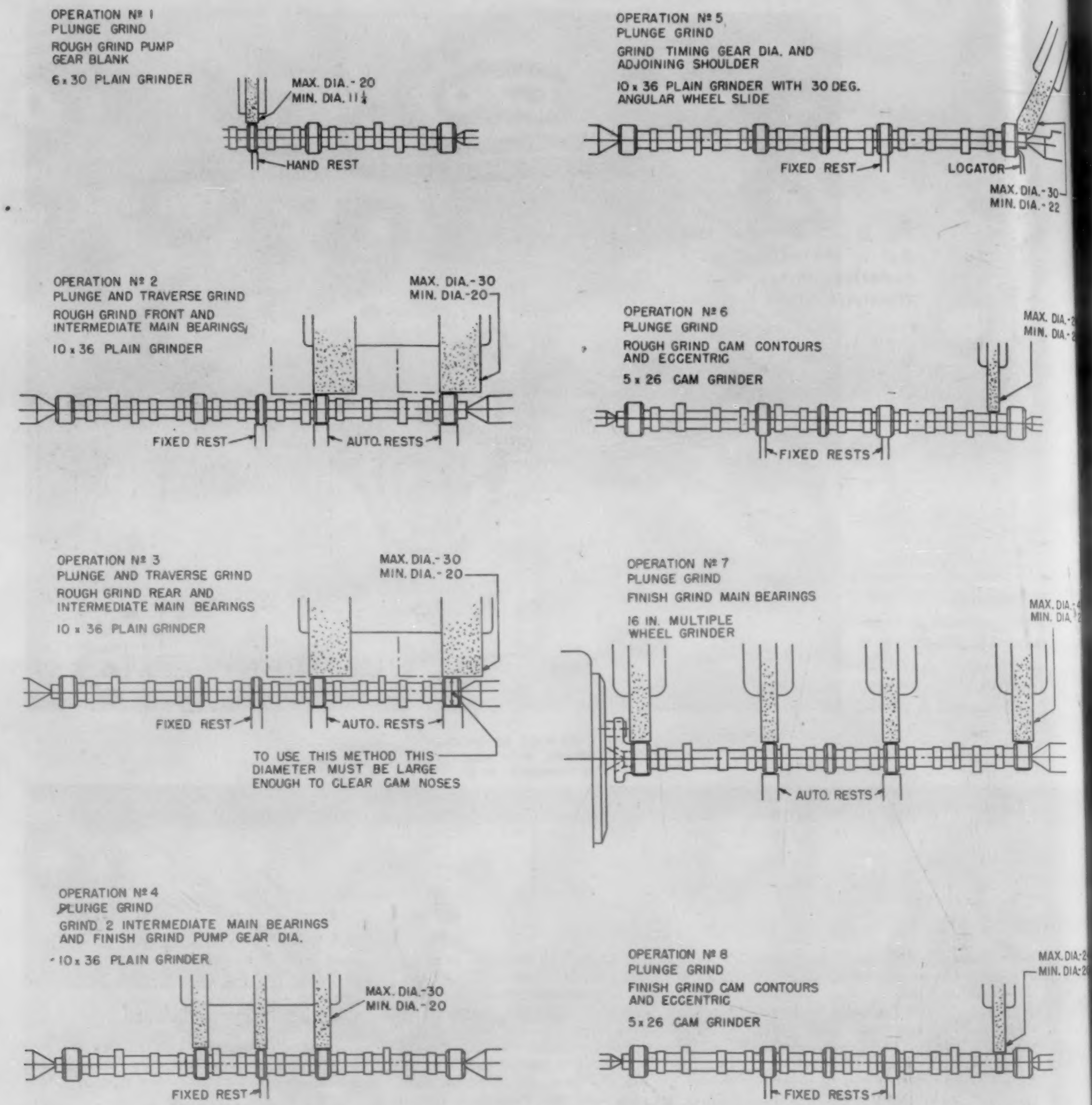


Fig. 32—Sketches of grinding set-ups employed in finishing an automotive camshaft. (Courtesy: Landis Tool Co.)

Acknowledgement

The helpful cooperation and aid in the supplying of data and/or photographs for this manual on the part of the following individuals or organizations is acknowledged with thanks:

Blanchard Machine Co., Cambridge, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Milling & Grinding Machines, Inc., Cincinnati, Ohio
H. J. Chamberland for the DoAll Co. of Des Plaines, Ill.
Ex-Cell-O Corp., Detroit, Mich.
Fitchburg Grinding Machine Corp., Fitchburg, Mass.
Heald Machine Co., Worcester, Mass.
Jones & Lamson Machine Co., Springfield, Vt.
Kaydon Engineering Corp., Muskegon, Mich.
Landis Tool Co., Waynesboro, Pa.
Mattison Machine Works, Rockford, Ill.
Norton Co., Worcester, Mass.
Pratt & Whitney Div. of Niles, Bement, Pond Co., West Hartford, Conn.
The Sheffield Corp., Dayton, Ohio
Thompson Grinder Co., Springfield, Ohio

CONTENTS NOTED

A monthly department dedicated as a forum for the interchange of ideas between readers and editors. All readers are urged to take advantage of this space and participate in the discussions presented.

llegheny Ludlum Carbides

o the Editor:

A number of our consumers and rospects have called our attention o page 419 in your August 1946 ssue (File Facts No. 118), on which ou give a comparison of the various rades of cemented carbides. These eople have all wondered why their ource of supply, which happens to e Allegheny Ludlum, was not listed n this table.

For the record, Allegheny Ludlum id much of the basic development ork on carbides when they were irst introduced in this country. At hat time we registered the trade-mark "Carmet." Late in 1944 we re-established our Carbide Manufactur-ng Division and made available a omplete line of carbide tools and lanks under the name "Carmet," in oth standard and special shapes.

C. B. Templeton

llegheny Ludlum Steel Corp.,
ittsburgh, Pa.

Through an unfortunate — indeed nforgivable — oversight, the "Car-met" carbides were not listed in our able of comparable grades of car-bides. We are extremely sorry that we are guilty of such an omission. We strive to be fair to all suppliers nd would not willingly slight one, nd, equally important, we aim to ive our readers all the information in File Facts *and all other departments of* MATERIALS & METHODS.—*The Editors.*

M & M "Must" Reading

To the Editor:

The writer has been a reader of your magazine for several years, and it has been quite helpful. Every issue is a "Must" reading for the entire organization.

John Christopher

Christopher & Principe,
Los Angeles 14, Calif.

We are happy that Reader Christopher finds MATERIALS & METHODS *helpful. According to a recent reader survey, many other readers include M & M on their "must" reading list. —The Editors.*

Cleaning Zinc Die Castings

To the Editor:

In the item "Tips on Cleaning Zinc Die Castings" in your *Shop Notes* department of the August 1946 issue there is one point which we think is subject to criticism. In the next to the last paragraph you state, "It is clear, therefore, that zinc die castings should not be cleaned anodically in detergents; . . ." That should be modified to read: "It is clear that zinc die castings should not be cleaned anodically in detergents *carrying silicates having two or more molecules of silica per mole of alkali;* but detergents containing meta- or sesquisilicate are entirely satisfactory for this operation."

Reference to the original paper by Hazel and Stericker shows that TSP, pyrophosphate, tetraphosphate and hexametaphosphate all attacked zinc when it was cleaned anodically, as did caustic soda. However, soda ash left the anode bright and specular, whereas in reversal of other experience, it gave trouble on cathodes.

C. H. Jeglum,
Ass't. to the Chemical Director

Philadelphia Quartz Co.,
Philadelphia 6, Pa.

The original statement was not in error, but since a complete explanation came later, Reader Jeglum felt that the restatement of facts would eliminate any misunderstanding and avoid confusion.—The Editors.

High Temperature Alloys

To the Editor:

We noted the article "Super Alloys for High Temperature Service" in the June 1946 issue of MATERIALS & METHODS immediately after it was published, and thought the material very well handled, particularly in view of the controversial subject matter involved. We will take the liberty of making a few points now

(Continued on page 941)

YOU GET MORE PRODUCTS PER TON WITH N-A-X HIGH-TENSILE STEEL

★

The High Physical Properties of This Low-Alloy Steel Can Make Your Sheet Steel Go 33% Farther

★

Smaller Sections Provide the Saving

N-A-X HIGH-TENSILE steel has the strength, toughness, fatigue- and corrosion-resistance to permit reductions up to 25% in sectional thickness when it replaces carbon sheet steels. These outstanding properties mean durability in your finished part or product. And they are translated into production increases up to 33%.

Good Formability Makes the Switch Feasible

N-A-X HIGH-TENSILE is exceptional among high-strength steels because of its unique combination of strength *and ductility*. It can be cold-formed to intricate shapes and deep-drawn to produce parts normally fabricated out of mild carbon steels. N-A-X HIGH-TENSILE has demonstrated its formability in scores of severe fabricating operations, and requires little or no change in die design or press capacity.

Three Tons Can Do the Work of Four

By designing sections to take advantage of the high physical properties of N-A-X HIGH-TENSILE, manufacturers can use less steel per unit, get more units per ton. How great this increase will be depends, of course, on the particular part or product. But it is entirely reasonable to expect that three tons of N-A-X HIGH-TENSILE can be made to produce as many units as four tons of carbon sheet steel.

NOW LET'S LOOK AT OVER-ALL COSTS

There is only one fair way to compare the price factor of N-A-X HIGH-TENSILE and carbon sheet steel, and that is on the basis of over-all costs. It is our conviction that N-A-X HIGH-TENSILE will "pay its own way" by increasing production per ton, and by making possible many economies in handling, fabricating and finishing. We are ready to work with you closely on your particular problem of using N-A-X HIGH-TENSILE to make a ton of steel go farther.

MAKE A TON OF SHEET STEEL GO FARTHER

Specify—

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HIGH-TENSILE STEEL

GREAT LAKES STEEL

Corporation

N-A-X ALLOY DIVISION • DETROIT 18, MICHIGAN

UNIT OF NATIONAL STEEL CORPORATION

CONTENTS NOTED

(Continued from page 939)

which we would have made prior to publication, had we had the opportunity.

Under "What the Metals Must Accomplish," it is noted that one authority has observed that more blade failures than wheel failures have been reported. This is a natural situation in view of the fact that the ratio of blades to wheels ranges from 50: to 150:1. Actually, the possibility of wheel failures has been of much more worry to the engineers and metallurgists than the possibility of blade failures.

It was stated that Haynes Stellite Co. turned out buckets for Ford and Allis-Chalmers. General Electric should be added to this list.

It is true that at 1200 F the high-temperature fatigue strength of the cast alloys with coarse grain is not as high as that of the fine-grained forgings or castings. It is not true at 1500 F, as the fatigue strength of the two types of materials is approximately the same. Recent results indicate that fine-grained castings have poorer fatigue strength than medium or coarse-grained castings in the cobalt-base alloys at 1200 F.

Late in the article it is stated that in the extreme heat of turbo-superchargers there is recrystallization that relieves strain. I do not believe this is a metallurgical possibility. It might, however, be argued that this higher temperature permits some slight plastic movement of the metal which would distribute strain more uniformly than at the lower temperature of operation of the I-40 jet buckets. In the same paragraph it is stated that G. E. spheroidized Hastelloy B at 1900 F for 24 hr., thereby getting everything to precipitate that would ever do so in service. Actually, such treatment was not particularly satisfactory in preventing further precipitation, but merely served to slow it down. The original heat treatment, which was not felt to be practical for production purposes, of 72 hr. at 1700 F was more satisfactory in preventing precipitation, but even that was not adequate in completely preventing this phenomenon.

In the analysis of Hastelloy C, the aluminum percentage of 1.0 is shown. This alloy does not carry any aluminum.

We believe your article must have received considerable attention and interest from your readers, and we consider its publication very timely.

F. S. Badger,
Vice President

Haynes Stellite Co.,
Kokomo, Ind.

We appreciate, and we are sure our readers will also, the comments offered by Dr. Badger. He and his company had a very great part in the development and manufacture of high temperature alloys. Haynes Stellite produces, in addition to the various grades of Hastelloy, Vitallium, 61 Alloy and X-40. The three alloys listed were developed in conjunction with other companies, but Haynes Stellite has supplied all the material of these analyses commercially used. —The Editors.

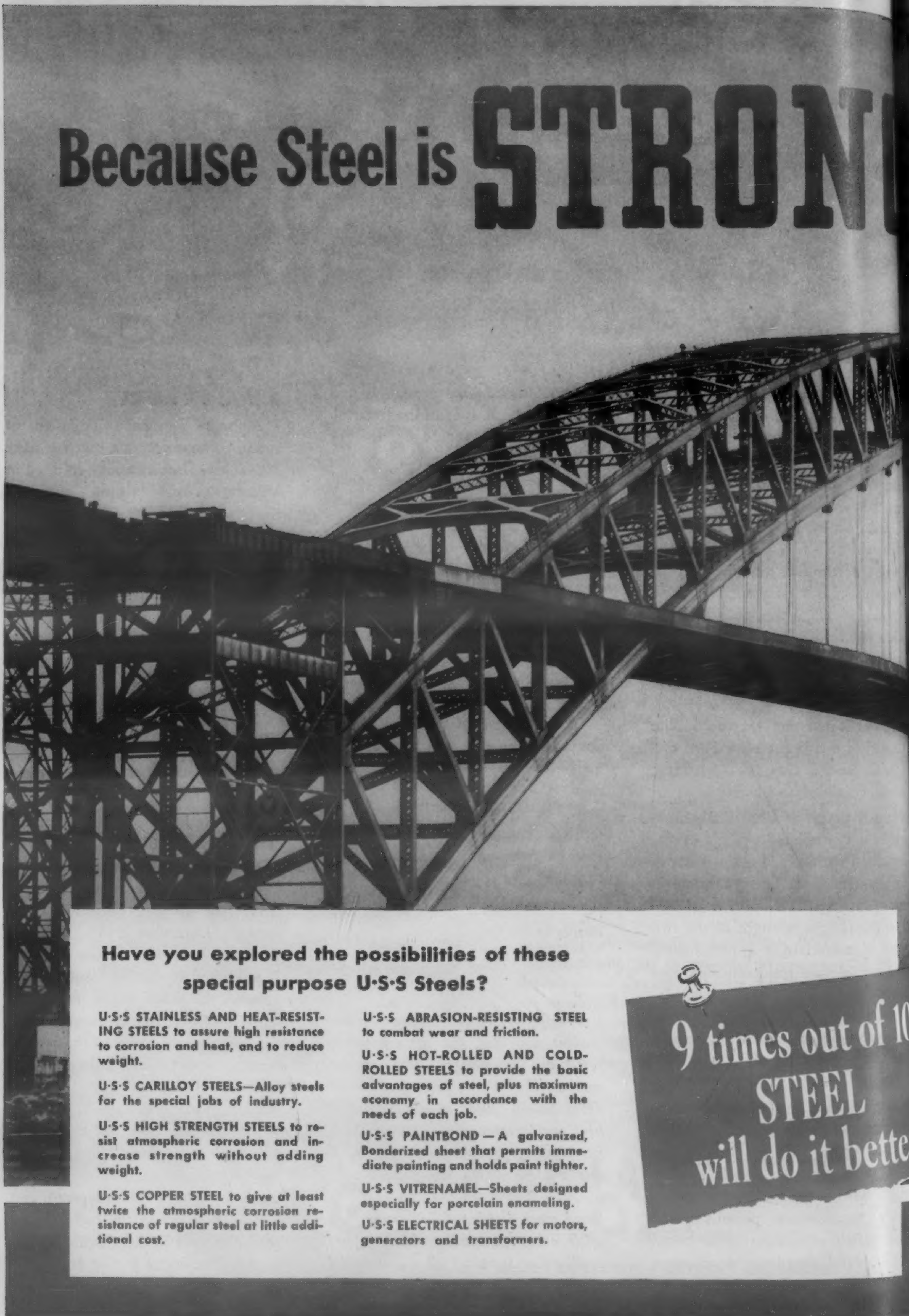
Reprints and Indexes

Many readers have suggested, in recent communications, that we make available reprints of data published in MATERIALS & METHODS—especially the Manuals and File Facts.

Each manual, as it is published, is immediately reprinted for distribution to interested readers. These reprints generally are available about three weeks after each issue of MATERIALS & METHODS is distributed. A charge of 25 cents per copy is made for reprints, to cover the cost of mailing, handling and billing. We still have on hand a few copies of each manual in the series from No. 6 on through the one appearing in this issue.

Other readers ask about indexes for MATERIALS & METHODS. Separate indexes were printed for this magazine and its predecessor—METALS AND ALLOYS to cover all issues through December 1945. Effective with the June 1946 issue, an index is published in the last issue of each volume. In other words, each June and December issue will carry an index covering the previous six months. Indexes cover all feature articles, MATERIALS & METHODS Manuals and Engineering File Facts.

Indexes are now published this way for two reasons: First, because in this manner each reader gets an index as soon as it is prepared, and, second, they are in the hands of the reader as soon as the volume is completed. The index in our June 1946 issue appeared on pages 1763 and 1764.



Because Steel is STRON
Have you explored the possibilities of these special purpose U·S·S Steels?
U·S·S STAINLESS AND HEAT-RESISTING STEELS to assure high resistance to corrosion and heat, and to reduce weight.
U·S·S CARILLOY STEELS—Alloy steels for the special jobs of industry.
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9 times out of 10
STEEL
will do it better

NUMBER 122
October, 1946

METHODS: Grinding

Some Characteristics of Standard Plain Grinding Machines

Manufacturer	Nominal Machine Size (in.)	Grinding Wheel Size, In. Standard Wheel	Max. Dia.	Max. Width	Auto. Wheel Feed In.	Max. Swivel Table Adjustment for Grinding Tapers, In. per Ft.	Work Speeds, Rpm.	Table Traverse Rates In. per Min.	Net Weight Lb. (Complete)	Floor Space Occupied by Machine In.
					Min. Max.					
A	3 x 12	14	14	2	0.00025 to 0.0045	3¾	202, 319, 505, 800	6, 11, 22, 39, 70, 133	2,610	42½ x 70¼
B	4 x 12	16 x 1	16	3	0.0002 to 0.003	3¾	200 to 900	3 to 120	4,000	50 x 73
D	4 x 12	16 x 1	16	2	0.0002 to 0.0050	5¾	175, 290, 460, 800	3 to 280	3,600	53-13/16 x 78⅞
C	4 x 12	16 x 3	16	—	—	—	100 to 1000 (var.)	—	4,300	55½ x 75½
A	6 x 18	24	24	4	0.0002 to 0.0046	3⅞	97, 154, 240, 383	7 to 360	5,650	66 x 75
B	6 x 18	20 x 1½	20	4	0 to 0.100	3½	95, 153, 246, 400	3 to 360	6,500	66 x 90
C	6 x 18	20 x 2	20	3	0.0001 —	4	80 (min.)	3 to 360	5,700	60 x 82
D	6 x 18	24 x 2	24	4	0.0004 to 0.0028	5	97, 165, 225, 395	3 to 240	6,100	74½ x 95⅞
A	10 x 18	24	30	7	0.0002 to 0.0046	4½	42 to 165 (var.)	15 to 300	8,500	75 x 92¾
B	10 x 18	30 x 3	30	5	0 to 0.120	3	51 to 140	3 to 240	10,200	90 x 126
B	10 x 36	30 x 3	30	12	—	1½	50 to 135	3 to 240	12,850	96 x 132
C	10 x 18	24 x 3	30	7	0.0001 —	3½	42 to 246	3 to 360	9,500	77 x 97
D	10 x 18	24 x 2	24	4	0.0004 to 0.0028	5	66, 111, 173, 268	3 to 240	6,300	74½ x 95⅞
D	10 x 18	30 x 3	30	6	0.0004 to 0.0028	5	46 to 292	3 to 220	8,600	83¾ x 112
B	14 x 18	30 x 3	30	5	0 to 0.120	3	51 to 140	3 to 240	10,500	90 x 126
B	14 x 36	30 x 3	30	12	0.0001 —	1½	50 to 134	3 to 240	13,050	96 x 132
C	14 x 36	30 x 3	42	10	—	3-7/16	9 to 68	6 to 264	17,400	86 x 149
D	14 x 18	30 x 3	30	—	0.0004 to 0.0028	5	76 to 292	3 to 220	9,000	86¼ x 112
D	14 x 36	30 x 3	30	7	0.0002 to 0.0012	3¼	40 to 160	7 to 120	13,300	88¼ x 163¾
B	16 x 96	30 x 3	—	—	—	—	25 to 100	4 to 78	27,500	120 x 288
C	16 x 36	30 x 3	42	10	—	3-7/16	9 to 68	6 to 264	18,000	86 x 149
D	16 x 36	30 x 3	30	7	0.0002 to 0.0012	3¼	25 to 100	7 to 120	14,300	88¼ x 163¾

These data were furnished by the machine tool builders whose products are listed in this table. The code letters in the first column refer to the leading manufacturers of precision grinders as follows:

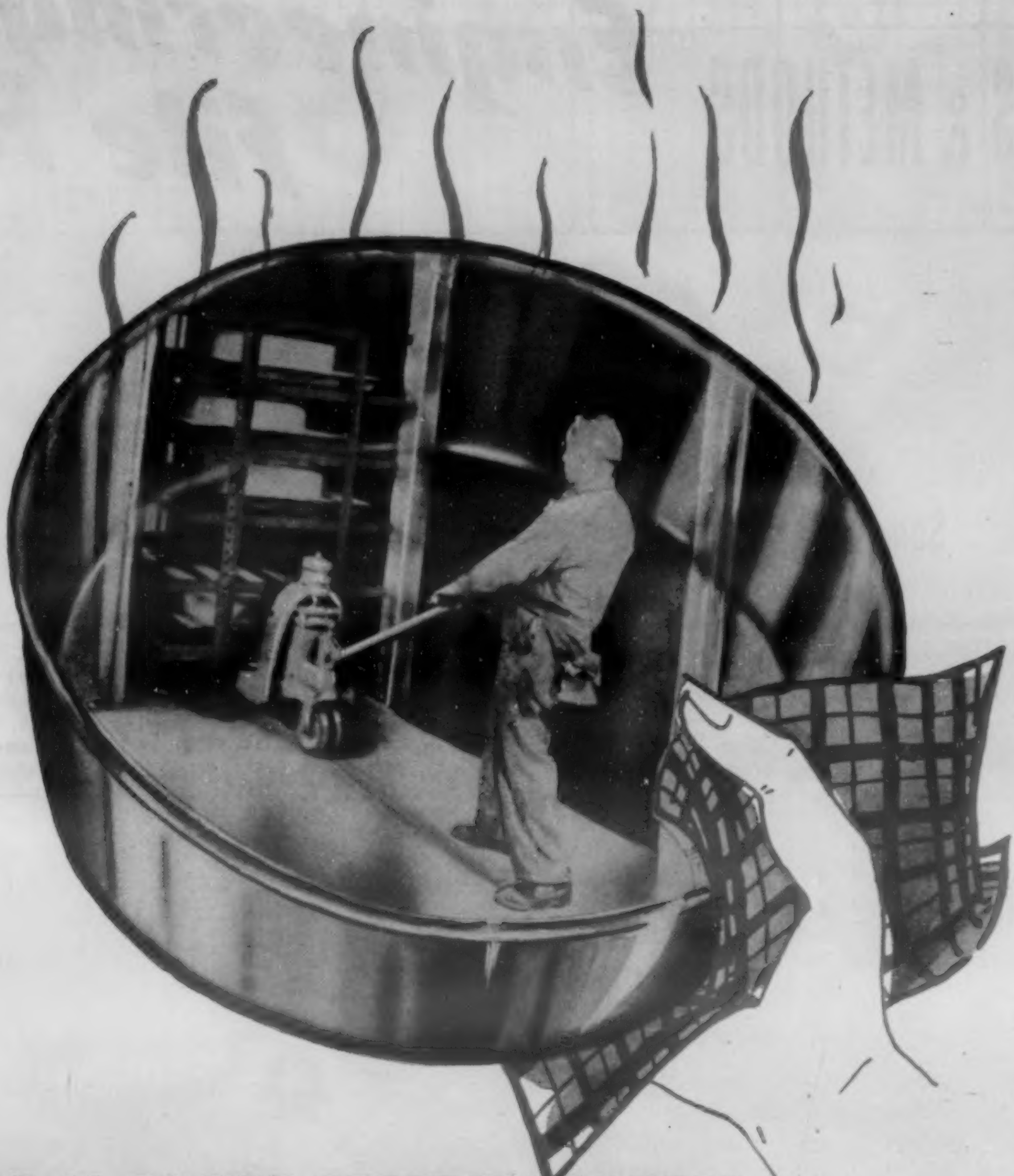
A—Brown & Sharpe Mfg. Co., Providence, R. I.

B—Landis Tool Co., Waynesboro, Pa.

C—Norton Company, Worcester, Mass.

D—Cincinnati Milling & Grinding Machine Co., Inc., Cincinnati, Ohio

Compiled by Robert S. Burpo, Jr.



MATERIALS & METHODS Engineering File Facts

NUMBER 123
October, 1946

MATERIALS: Steels

Standard Steels

Basic Open-Hearth and Acid Bessemer Carbon Steels for Hot-Rolled Bars

AISI Number	Chemical Composition Limits, %			
	C	Mn	P, Max.	S, Max.
C 1008	0.10 max.	0.30/0.50	0.040	0.050
C 1010	0.08/0.13	0.30/0.60	0.040	0.050
C 1012	0.10/0.15	0.30/0.60	0.040	0.050
C 1015	0.13/0.18	0.30/0.60	0.040	0.050
C 1016	0.13/0.18	0.60/0.90	0.040	0.050
C 1017	0.15/0.20	0.30/0.60	0.040	0.050
C 1019	0.15/0.20	0.70/1.00	0.040	0.050
C 1020	0.18/0.23	0.30/0.60	0.040	0.050
C 1022	0.18/0.23	0.70/1.00	0.040	0.050
C 1023	0.20/0.25	0.30/0.60	0.040	0.050
C 1025	0.22/0.28	0.30/0.60	0.040	0.050
C 1030	0.28/0.34	0.60/0.90	0.040	0.050
C 1035	0.32/0.38	0.60/0.90	0.040	0.050
C 1040	0.37/0.44	0.60/0.90	0.040	0.050
C 1043	0.40/0.47	0.70/1.00	0.040	0.050
C 1045	0.43/0.50	0.60/0.90	0.040	0.050
C 1050	0.48/0.55	0.60/0.90	0.040	0.050
C 1055	0.50/0.60	0.60/0.90	0.040	0.050
C 1060	0.55/0.65	0.60/0.90	0.040	0.050
C 1065	0.60/0.70	0.60/0.90	0.040	0.050
C 1070	0.65/0.75	0.60/0.90	0.040	0.050
C 1078	0.72/0.85	0.30/0.60	0.040	0.050
C 1080	0.75/0.88	0.60/0.90	0.040	0.050
C 1085	0.80/0.93	0.70/1.00	0.040	0.050
C 1095	0.90/1.05	0.30/0.50	0.040	0.050
B 1010	0.13 max.	0.30/0.60	0.07/0.12	0.600

NOTE 1: *When silicon is specified in standard basic open-hearth steels, silicon may be ordered only as 0.10% maximum; 0.10 to 0.20%; or 0.15 to 0.30%. In the case of many grades of basic open-hearth steel, special practice is necessary in order to comply with a specification including silicon.*

NOTE 2: *Acid bessemer steel is not furnished with specified silicon content.*

Basic Open-Hearth Sulphurized Carbon Steels for Hot-Rolled Bars

AISI Number	Chemical Composition Limits, %			
	C	Mn	P, Max.	S
C 1109	0.08/0.13	0.60/0.90	0.045	0.08/0.13
C 1112	0.10/0.16	1.00/1.30	0.045	0.08/0.13
C 1115	0.13/0.18	0.70/1.00	0.045	0.08/0.13
C 1116	0.14/0.20	1.10/1.40	0.045	0.16/0.23
C 1117	0.14/0.20	1.00/1.30	0.045	0.08/0.13
C 1118	0.14/0.20	1.30/1.60	0.045	0.08/0.13
C 1120	0.18/0.23	0.70/1.00	0.045	0.08/0.13
C 1137	0.32/0.39	1.35/1.65	0.045	0.08/0.13
C 1141	0.37/0.45	1.35/1.65	0.045	0.08/0.13
C 1144	0.40/0.48	1.35/1.65	0.045	0.24/0.33
C 1145	0.42/0.49	0.70/1.00	0.045	0.04/0.07
C 1151	0.48/0.55	0.70/1.00	0.045	0.08/0.13

NOTE: *Sulphurized steel is not subject to check analysis for sulphur. Phosphorized steel is not subject to check analysis for phosphorus.*

Acid Bessemer Sulphurized Carbon Steels for Hot-Rolled Bars

AISI Number	Chemical Composition Limits, %			
	C	Mn	P	S
B 1111	0.08/0.13	0.70/1.00	0.07/0.12	0.10/0.15
B 1112	0.08/0.13	0.70/1.00	0.07/0.12	0.16/0.23
B 1113	0.08/0.13	0.70/1.00	0.07/0.12	0.24/0.33

NOTE 1: *Sulphurized steel is not subject to check analysis for sulphur.*

NOTE 2: *Acid bessemer steel is not furnished with specified silicon content.*

Data furnished by the American Iron & Steel Institute

engineering

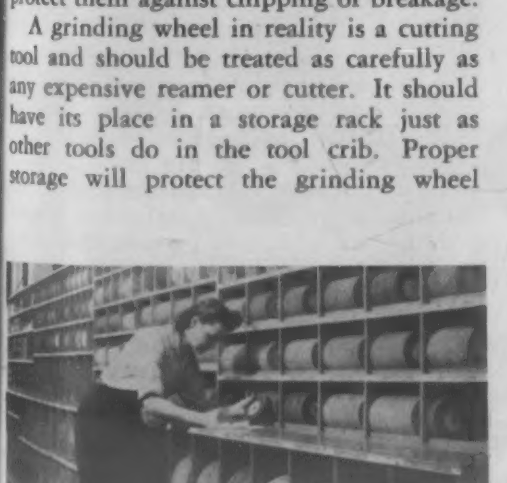
SHOP NOTES

Proper Storage of Grinding Wheels

by Francis D. Hart, Jr.,
Norton Company

The majority of grinding wheels are capable of withstanding ordinary handling and use without danger of damaging them. However, when the wheels are not in use, they should be carefully stored to protect them against chipping or breakage.

A grinding wheel in reality is a cutting tool and should be treated as carefully as any expensive reamer or cutter. It should have its place in a storage rack just as other tools do in the tool crib. Proper storage will protect the grinding wheel against chipping or breakage and enable it to be quickly located.



This picture is a good example of how grinding wheels should be stored.

Grinding wheel storage racks should be so designed, constructed and located as to best fulfill the needs of the user. There are several factors that should be kept in mind when selecting the storage site. First, the room in which grinding wheels are stored should not be damp or subjected to extreme temperature changes, as organic bonded wheels are sometimes affected by such conditions. Grinding wheels should be stored in a dry area.

A second important point to consider is the location of wheels in the racks and a system of wheel identification. Each separate section of the storage rack should be plainly marked, preferably with the wheel manufacturer's marking, so that wheels can be quickly located. The majority of straight wheels (except thin wheels such as cut-off) and some shaped wheels are usually stored in racks or on shelves so constructed that there is no danger of the wheels rolling off.

Cut-off and other wheels 3/16-in. thick and less should be laid flat on a plane surface that is free from any imperfections and not likely to warp. A machined steel plate is ideal for this purpose. Saucer, cup and straight wheels may be stored flat in stacks, or on edge, depending upon the particular shape and the thinness of the edge. Small straight cup wheels are more often stood on edge, whereas tapered cups are better nested in stacks. Cup wheels over 6 in. in dia. and all cylinder wheels should be piled flat, one on top of another.

Small internal, straight, recessed and shaped wheels as well as mounted points, 2 in. or less in dia., are best protected by placing them in boxes or drawers with the contents plainly labeled on the outside.

A gas burner installed on a slitting machine has materially eliminated loss due to breakage when slitting silicon sheet steel. While silicon steel is extremely brittle and difficult to work, it does have certain electrical characteristics that make it invaluable in the design and construction of electrical equipment. The burner is attached to the front of the slitter and is connected to the shop air and gas lines. Before the steel enters the slitter it is fed over the burner, which is adjusted to heat the metal to the proper working temperature. (C. Choquette, Westinghouse Electric Corp.)

Tips on Saving Tin

by C. E. Heussner & E. T. Johnson, Chrysler Corp.

Tin continues to be scarce. Even though the war is over, tin will be one of our hard-to-get metals for at least the next year or two. The scarcity of tin prompted Chrysler Corp. to develop new methods which resulted in a saving of over half the tin formerly used. Whereas in 1940 a ton of tin was needed for every 480 cars, the same amount will now fulfill the requirements of over 1000 cars.

To accomplish this saving of tin, a number of methods and materials changes have been made:

Body solder, used as a filling material to give a smooth finish and sleek, uninterrupted body lines to a car, and formerly using 15% tin, has been developed to the point where a solder containing no tin at all is performing an equally satisfactory job. The new solder provides all of the flowing characteristics and ease of forming necessary for the job.

The soldering of fittings to gasoline tanks has been replaced by spot-welding, using a plastic gasket where a seal is needed. In certain places where the use of tin solder for sealing is still required, the content of tin has been reduced from as high as 40% down to 10%. Joints are neater, and frequently stronger than the steel around them.

Prior to the war, aluminum pistons were coated with tin to lubricate them properly so that they would withstand the severe "scrubbing" action against the cylinder walls. A new brass coating has been developed which works equally well, again saving tin.

It has been found that the greatest savings in tin can be accomplished by: (1) parts redesign to eliminate the use of tin; (2) changing the processing method to reduce the amount of tin; and (3) using alternate materials in the place of tin.

A new body solder has been developed containing no tin. The replaced solder contained 15% tin.

Our cupboard is almost bare. We need some good Shop Notes to stock it again. So don't hesitate to send in your kinks and ideas on how to do a job better. We pay for those published, too.

Shot Blasting Aids Automotive Parts

by John G. Wood & R. F. Sanders, Chevrolet Motor Div.

During the war there was a constant search for substitute materials for vital parts of automotive equipment, such as steering knuckles, where perhaps human life was involved in the soundness of the metal. Often as soon as a substitute was tested and proved satisfactory, it became scarce and new substitutes had to be tested.

In normal times materials are appraised by road testing, thus duplicating severe service conditions. During the war, however, it was necessary to perform accelerated tests in the laboratory, called the "stroking" test. After establishing definite cycles for failure, it is apparent that material comparisons can be made quickly.

The load applied is calculated by measuring the deflection of a ring built in the piston rod, the gage being calibrated in pound load. A total of 128,000 cycles for failure was taken as the absolute minimum acceptable. The ratio of the low and high fatigue lives was used as a means of measuring the consistency of the material. The ideal ratio would, of course, be 1:1.

When the high alloy steels were no longer available, we turned to the National Emergency steels. The ninth test of our series involved NE 8744, containing 0.5% nickel and chromium. The best sample endured 416,561 cycles; the low only 124,400 cycles, thus with the poor ratio of 3.34:1. The low was, of course, under the minimum of 128,000 cycles. We considered the material fairly satisfactory yet borderline material.

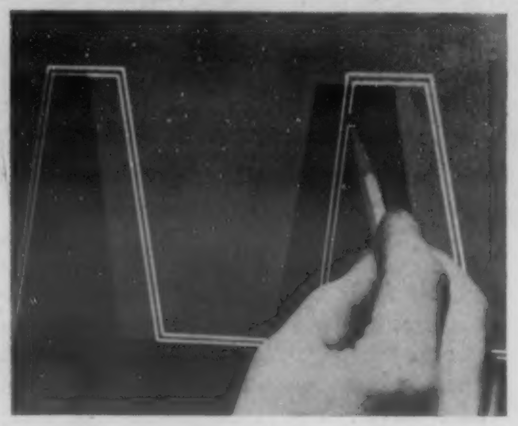
Whereupon we obtained samples of the same NE 8744 steel that were shot blasted at all areas subject to stress concentrations. The poorest sample endured 639,000 cycles and the best, 1,636,980, with ratio of 2.56:1. The fatigue lives of the shot blasted material were far greater than for any of the materials tested and showed that great benefit is derived from shot blasting or peening.

Thus, it was possible to develop steering knuckles of much less critical material than originally used and having a greater fatigue life than original production. Also, minor design changes and improvement in machining the fillets were a major help in improving fatigue life. Shot blasting was also found effective in making transmission gears, made of CX-4120 steel (no nickel and 0.60 to 0.80% chromium). NE 8620 was found a satisfactory substitute, if shot blasted.

New Scribing Plate for Precision Work

A new type scribing plate has been developed by the Eastman Kodak Co. for use with optical comparators of the contour projection type. The plates may be used directly with the contour comparators or as printing masters for photographically duplicating the contour comparator plate. Also, they may be used for making small photo templates on metals, plastics and other materials.

The new product consists of a transparent green-dyed gelatin coating applied to glass. Tolerance lines are scribed on the plate by cutting through the gelatin film. With conventional glass plates, hydrofluoric acid is required to etch the plates. The entire execution of comparator plates may be left in the hands of a skilled draftsman.



This picture illustrates the use of the new scribing plate. The piece under examination has been shifted to illustrate how the tolerance lines in shaded areas are brought into sharp relief when using a supplemental red light behind the gelatin-coated plate.

By using a supplemental red light behind the plate, tolerance limits in shadowed areas are brought into sharp relief, showing as red lines against the dark green background. On precision grinders equipped with contour comparators, this permits the machine operator to see exactly how much material must be cut away to attain the desired dimensions.

Where the original scribed pattern is symmetrical, duplicate plates can be printed directly from the original on photographic plates. Since such a copy is a "mirror image", however, unsymmetrical patterns should be scribed in reverse or else the final duplicate should be printed from a master plate prepared from the original.

A unique and rapid method of determining the approximate humidity is through the use of small, sensitized labels that change color with humidity. Known as Hygrolabels, they are a brilliant blue-green when dry, and pink when the humidity approaches the point where mold, mildew, corrosion and rust takes place. (Eljay Enterprises)

New Device Aids Low-Temperature Research

Interest in low-temperature research has increased greatly in recent years. An aid to the research work is the recent development by Professor S. C. Collins, of Massachusetts Institute of Technology, of a relatively simple apparatus which makes readily available any temperature down to 2 deg. Absolute, or —457 F.

At extremely low temperatures, much can be learned about the solid state of matter. At room temperature, minute influences within the molecule are obscured by the relatively tremendous thermal motion of the molecule, but in the range near absolute zero, or about —459.4 F, these minute internal influences become the governing ones. At absolute zero, there is virtually no thermal motion; the molecules are literally "frozen in their tracks," and their properties can be more readily examined and more accurately measured.

Low-temperature research is useful in studies of the electronic structure of metals and semi-conductors, magnetic phenomena, the molecular structure of crystals, and other basic phenomena. Many metals lose all their electrical resistance at temperatures below 7 deg. Absolute. Research is now under way to investigate this superconductivity with extremely short radar waves.

Perhaps the most important research at low temperatures has been carried on to determine the characteristics which govern the behavior of chemical substances at any temperature by measuring the heat capacity, or the quantity of heat necessary to raise the temperature of the substance from near absolute zero to the temperature in question. Knowing these physical characteristics, one can predict the chemical properties of the material.

Research in the low-temperature range has heretofore been limited for the most part to certain fixed temperatures, such as those of liquid oxygen, nitrogen, hydrogen, or neon. The new device for obtaining sub-zero temperatures, known as the helium cryostat, can be so operated that its generation of cold just balances heat leakage into it or heat generated by experimentation, and any desired temperature may be maintained.

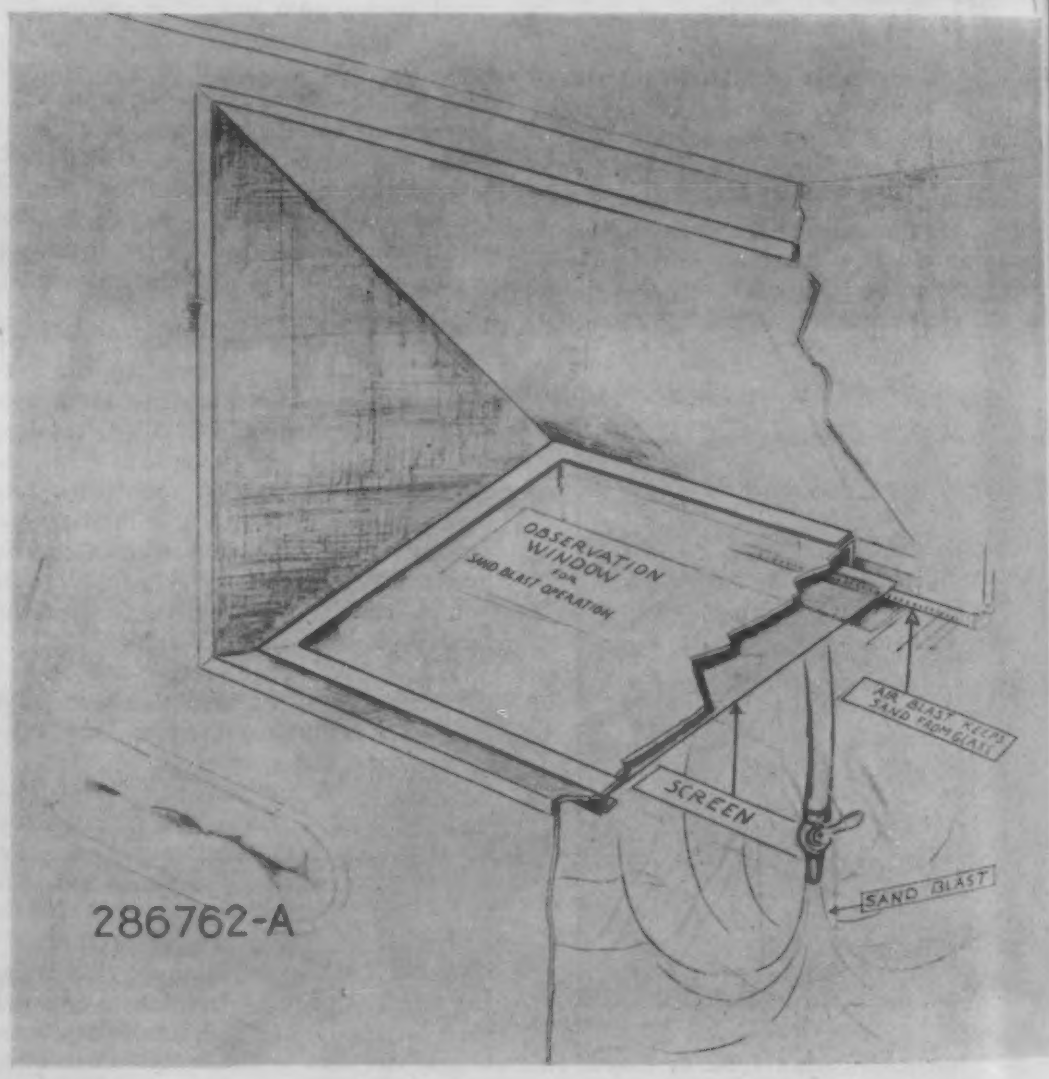
The helium cryostat operates by circulating gaseous helium at moderate pressure through a heat exchanger, and then expanding it through an engine where it does work; consequently, more heat is removed from the helium than if it were expanded in the conventional manner through an orifice. This engine is the heart of the process, thermodynamically. It must handle one of the thinnest known fluids with high efficiency but without lubrication and without friction, for at these low temperatures lubricants solidify and ordinary steel becomes exceedingly brittle. By constantly circulating helium and cooling it in the heat exchanger with the cooler helium from the engine exhaust, any heat leakage due to imperfect insulation or the experiment itself may be counteracted.

As contrasted with the tons of special equipment operated at pressures up to 3,000 psi. to produce liquid helium by some other methods now in use, the present device weighs approximately one-half ton, three-quarters of which is devoted to the compressor and drive, and it operates at only 200 psi. pressure.

The new cryostat is expected to find important use in metallurgical research on thermal conductivity, embrittlement, and many other characteristics of metals and alloys. Present metals attain only a small fraction of the strength which theoretical consideration of the forces between and within molecules shows to be possible. Perhaps a better knowledge of the characteristics of molecules and atoms through low-temperature research will some day bring these theoretical goals closer to actuality.

—*From "The Industrial Bulletin" of Arthur D. Little, Inc.*

Would you, manufacturer, like to know how your products would hold up in the jungles of the tropics? Then you can create similar conditions in your own backyard, or perhaps laboratory—complete except for the Bali Bali dancing girls (hot, but not humid). Dr. Peter Gray, University of Pittsburgh, has led the way. Put some glass jars in a room kept at 90 F. Cover the bottom of each jar with moss, saturated with water to maintain humidity of 60 to 80%. Place small chunks of bread atop the moss, placing an air-tight lid on the jar. The mold forming on the bread is infected with other types of organic growth, and various little "gardens" are allowed to germinate. When fungi, bacteria, mites, etc. have reached a robust stage, place samples of equipment to be tested in these jars. A month's exposure in these "junior hot-houses" is equivalent to 6 mo. or a year in the Panama Canal Zone. Dr. Gray's tests have revealed that varnishes of the phenol-formaldehyde group are markedly resistant. (Westinghouse Electric Corp.)

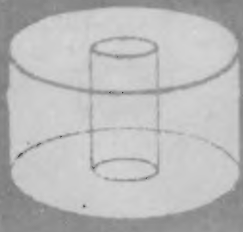


Air Curtain Protects Sand Blast Observation Window—*Using a curtain of air to protect the observation window of a sand blast room from pitting, engineers at the Bloomfield, N. J., Lamp Div. of Westinghouse Electric Corp. have reduced the number of replacements as much as 90%. A ¼-in. pipe in which a number of holes have been drilled is mounted along the top of the window on the under side of the glass. As illustrated, the air forms a curtain across the window and deflects sand particles away from the glass. The pipe can be installed in any sand blast equipment by following the plan shown in the sketch.*

MATERIALS & METHODS

DIGEST

A selection of outstanding articles on engineering materials and processing methods in the metal-working industries.



dited by Robert S. Burpo, Jr.
Associate Editor,
Materials & Methods

MATERIALS and DESIGN

Metals and Alloys

Nonmetallic Materials

General Product Design

METHODS and PROCESSES

Melting and Casting

Fabrication and Treatment

Testing and Inspection

METALS and ALLOYS

Engineering properties and applications of carbon, alloy and stainless steels, irons and nonferrous metals and alloys. Selection and evaluation of metallic materials for engineering service. New alloys and modifications.

Grain-Growth Inhibitors in Steel

Condensed from "Metals Technology"

A gradient-temperature furnace was used for heating samples in this investigation. The muffle is made of ½-in.-thick heat resisting plate. Heat is provided by two Globar heating elements placed just beyond the back end of the muffle. Specimens consist of ½-in. sq. bars 5 in. long.

The position of the muffle and the setting of the control couple to produce the desired gradient were determined by trial. About 2 hr. is required for the furnace to reach a stable condition. The furnace is checked with a dummy sample before each run.

Low carbon samples are oil-quenched from the furnace, sectioned longitudinally, polished, and etched in nital. The temperature range during which grain coarsening occurs shows very clearly on the etched bars. Tests are usually run for periods of 2, 4 and 8 hr. There is a slight decrease in grain-coarsening temperature with increasing time.

The effect of aluminum, titanium and zirconium on grain coarsening was investigated by adding ¼, ½, 1, 2 and 4 lb. of the elements per ton to a series of sucessive ingots of an open-hearth heat. Samples were taken from the middle cut of each ingot and forged to 1-in. rounds, which were used for grain-coarsening and physical tests. Steels of about 0.30% carbon, 0.80% manganese and 0.25% silicon were used for all of the series. Before grain-coarsening or physical tests were made, the samples were normalized from 1600 F.

Results indicate that aluminum is most effective as a grain-growth inhibitor when 0.028% as acid-soluble aluminum is present. It is difficult to reconcile this critical amount with any theory involving grain-growth inhibiting by an aluminum oxide. The mechanism of grain-growth inhibiting by titanium is much less complex than that of aluminum.

The simple relation between titanium content and coarsening temperature is compatible with, though not proof of, grain-growth inhibiting by titanium carbide. Zirconium is less effective than either aluminum or titanium as a grain refiner.

The improvement in notched-impact resistance at low temperatures by these elements is more of a direct alloying effect than the result of grain refinement. The latter does improve the notched-impact resistance, and it is therefore difficult to distinguish alloying and grain-refining effects. Considering alloying effects alone, aluminum and zirconium are beneficial to low-temperature impact resistance, and titanium is detrimental. (James W. Halley. *Metals Technology,* Vol. 13, June 1946, Tech. Pub. No. 2030, 11 pp.)

Aluminum and Music

Condensed from "Modern Metals"

As a demonstration that aluminum has fine tonal qualities, the Aluminum Co. of Canada at an entertainment in December, 1945, presented aluminum chimes, an instrument composed of 15 cast aluminum covers (alloy AC 123), originally made for pots and pans. The covers were screwed on wooden pegs in two rows, the lower corresponding to the white keys on the piano and the upper ones to the black keys. The covers were lined up chromatically from C^3 to D^8.

The domelike shape of the covers apparently accounts for their musical tone. They are made in four diameters ranging from 6½ to 10½ in. The first set tested gave out a perfect major chord, with the doubling (one octave higher) of the fundamental note of the chord. The vibrations lasted over 30 sec., sometimes 40 to 50 sec., whereas piano strings do not vibrate for more than 30 sec., unless struck very hard and in the lower range.

The covers were made to vibrate with a wooden mallet, the striking point being the shoulder of the cover, close to the edge. The only trouble was that the vibrations carried on too long, making for confusion, there having been no dampening device. The covers can be made to vibrate with a violin bow, such vibrations lasting over a minute. When sand is placed on the inside of the cover, the vibrations shape the sand into a 4-point star.

To fill in gaps in the chromatic scale it was decided to scrape the inside surfaces of some of the covers, thereby making them thinner. It was expected that this would give them a higher pitch, but the contrary resulted. It was concluded from study that the diameter of the cover is a basic factor in the number of vibrations per sec.

Larger covers give lower notes because the vibrations, having a larger territory to cover, take more time to come back to their starting point. Hence, the vibrations are slower and the pitch is lower.

The reduction in weight, whether through scraping or at time of casting, reduces the tempo of the vibrations, making for lower tone. Perhaps the modulus of elasticity is altered by scraping, or a little less metal is poured at casting.

When struck by the mallet or scraped by the violin bow, molecules bounce back to their starting point, forming vibrations. The faster this bouncing back, the faster the vibrations. One speed factor is the rigidity and thickness of the metal, *i.e.,* its degree of resistance.

It should theoretically be possible to take any cover and scrape it gradually to secure all possible notes, but actually the foundation of the musical tone would soon be ruined, especially the richness of the harmonics. The normal ratio of the decrease in vibrations is 16:15. When one scrapes to reduce by a half tone one removes metal by the same ratio.

As a result of this demonstration by the Aluminum Co. of Canada, it is felt that an exploration of musical possibilities of aluminum alloys would be of high interest to both the musical profession and to the aluminum industry. Perhaps some time the "brass section" of an orchestra will be the "aluminum" section. (Francois Hone. *Mod. Metals,* Vol. 2, July 1946, pp. 17-19.)

Gray Iron Wear Resistance

Condensed from "American Foundryman"

Structures recognized as having the best wear properties may be described as having a fully pearlitic matrix with the A.F.A. Type A graphite. In this discussion, comments are confined to those machine parts which occasionally fail because of differences in the cast iron structure and not because of inadequate lubrication or high bearing pressures, etc.

Various gray iron structures can be classified in order of their decreasing wear

resistance: (A) Refined and comple pearlitic matrix with A.F.A. Type graphite; (B) coarse pearlitic matrix w A.F.A. Type A graphite; (C1) pearl with a small amount of free ferrite ma with A.F.A. Type A graphite; (C2) pearl with a small amount of free cemen matrix with A.F.A. Type A graphite; (D abundant ferrite matrix with A.F.A. Type graphite; (E) abundant free cement matrix with any form of graphite; (F secondary ferrite matrix associated wi dendritic graphite, A.F.A. Type D or graphite. However, this discussion is n so much on the degree of wear resistan of different gray irons as on preventing t undesirable structures for optimum we properties in gray iron machine parts.

All of the factors influencing the produ tion of Types D and E graphite can b overcome by careful foundry control, an their effects on graphite structure can b efficiently prevented by adequate inocul tion of the metal just before pouring th castings. Inoculation is a gray iron found term meaning the addition of silicon, or i combination with other metals—iro nickel, calcium, chromium, etc.

These late additions have two effect (1) They provide final deoxidation melt (very common metallurgical practic indeed); and (2) they provide seeding o the melt with relatively concentrated silico which initiates early graphitization durin freezing.

A few details about inoculation whic the foundryman should bear in mind ar temperature of metal inoculated should no be below 2750 F; the inoculant should b fused into the metal without burning— powdered silicon, for example, burns readil with a blue flame and is, therefore, ineffec tive; adjustment of the composition i necessary to accommodate the ladle additio of silicon and its combined alloys. (F. G Sefing. *Am. Foundryman,* Vol. 9, Jun 1946, pp. 77-79.)

Aluminum-Steel Trolley Wires

Condensed from "Revue de l'Aluminium"

The copper wire used in the past ha had several disadvantages: (1) relatively high loss by mechanical wear; (2) appear ance of flaws under certain conditions which caused numerous ruptures; (3) th apparatus used for joining segments de creased the life of the wire; (4) welding was unsatisfactory as the welded joints wer not as strong as the original wire; and (5) sensitivity to annealing and therefore weak ening in case of large or abnormal loads Furthermore, France must import copper.

The choice among the many possibl substitutes depends upon the conditions o service. Any replacement should hav physical and mechanical properties equa to copper as well as a satisfactory life Various solutions are possible: (1) use o a composite system with a contact wire o iron or mild steel attached rigidly to a cable of aluminum, aluminum-steel o

(Continued on page 964)

Yes, Bunker Hill Zinc is 100% ore-zinc. Secondary materials of any kind are not used in the production of the zinc. Special care is taken to avoid contamination of the metal. Dross formed in the melting of the cathode zinc, is sold and not re-treated in the plant. Scrap, skimmings and cleanings from around the furnace and moulds, are melted in a separate furnace and converted into zinc dust instead of being returned to the main furnace.

Every precaution is taken to keep Bunker Hill Zinc uncontaminated. That their metallurgists are successful in this important control work is evidenced by the fact that this pure metal runs consistently 99.99+% zinc content and is practically free of lead.

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Almelec-steel; (2) semi-catenary sy[stem] with a number of flexible connections [be]tween the carrying cable and the c[ontact] cable; (3) system of various wires [elec]trically more resistant than copper in [par]allel with accompanying feeders of alu[mi]num, aluminum-steel or Almelec; and (4) simple contact wires installed in the s[ame] way as copper wires. Various prob[lems] connected with each of these are co[nsid]ered.

The mechanical properties of alumi[num] wire do not permit its use as a co[ntact] wire. Therefore, wire of Almelec or alu[mi]num-steel must be used. The Almelec c[an]not be obtained in long lengths so nu[mer]ous joints would be required. Also, it h[as] shown a high loss by wear, as much as [...] times as great as that of copper of [the] same section. Consequently, it is not r[ec]ommended.

The aluminum-steel wire is very sa[tis]factory. The aluminum supplies the h[igh] conductivity while the steel resists [the] wear. A composite wire of 0.062 sq. [in.] of steel and 0.124 sq. in. of aluminum [is] equivalent to a 0.093 sq. in. section [of] copper. The composite section must [be] designed so the wear is taken by the st[eel]. Many actual profiles of aluminum-st[eel] wires are shown. The joints are weld[ed].

The experience with these alumin[um]-steel wires has shown that they are [...] satisfactory on the whole, even though r[e]designing of the wire has been neces[sary] in some conditions. (L. Albert. *Revue [de] l'Aluminium*, Vol. 118, Jan. 1946, p[p.] 14-23.)

Precipitation-Hardened Aluminum-Zinc-Magnesium-Copper Forging Alloys

Condensed from "Aluminium"

The influence of the different contents of zinc, magnesium and copper on the me[]chanical and corrosion behavior of alumi[]num-zinc-magnesium-copper alloys w[as] studied in six alloys. It was found that th[e] alloys with 3.7% zinc, 2.5% magnesium, 1.5 to 2% copper, 0.7% manganese an[d] with 4.5% zinc, 1.5% magnesium, 1.5 [to] 2% copper, 0.7% manganese are abo[ut] equivalent as regards mechanical strength and reach the minimum values of strength required by the Flw. 3115 standards eve[n] by cold precipitation-hardening.

With regard to stress-corrosion behavior the alloy with 4.5% zinc, 1.5% magnesium was decidedly superior, especially after heating to 122 to 212 F, so that this ma[]terial gives to other aluminum-zinc-mag[]nesium-copper alloys a good surface protec[]tion against corrosion if mechanically plated with it.

Hot-precipitation-hardening (212 to 248 F) produces considerable increase of tensile strength and elastic limit with loss of elongation, which reduces resistance against stress-corrosion. This can be eliminated by plating (mechanically) with aluminum-magnesium-silicon. (K. L. Dreyer & H. J. Seemann. *Aluminium*, Vol. 26, 1944, p[p.] 76-82.)

NONMETALLIC MATERIALS

Design-uses of plastics, plywood, fibre, glass, rubber, ceramics, etc. as engineering materials. Composite metal-nonmetal combinations. New forms of nonmetallic materials.

Core Materials for Laminates

Condensed from "Plastics"

The problem of selecting the best core material for laminated sandwich structures for aircraft and other applications is investigated here. The materials covered in the survey included a cellular hard rubber, a cellular glass, balsa wood, and four expanded plastics—cellulose acetate, polystyrene, a urea-formaldehyde, and a zein (protein) base product.

The purpose of the investigation was to learn the physical and mechanical properties of some expanded plastics and other low-density materials available from commercial sources as an aid in the selection of materials for specific applications. The properties determined were: density; thermal conductivity; dimensional stability; resistance to water, lubricating oil, gasoline, and other chemicals; flexural and compressive strengths; and moduli of elasticity.

The densities of the materials tested, in gm/cc., were polystyrene 0.02, urea formaldehyde 0.04, hard rubber 0.07 to 0.08, low-density balsa 0.07 to 0.09, and cellulose acetate 0.08 to 0.09. The Foamglass and zein product had densities of about 0.17 and the high-density balsa 0.16 to 0.32 gm. Since the densities and cellular structure of an expanded plastics may be varied to some extent, the materials cannot be rated on the density.

The procedures for test were similar in general to those described in Federal Specification L-P-406a. The specimens for the various tests were conditioned at 77 F and 50% relative humidity for at least two days prior to test, and tested under those conditions (with a few exceptions). The thermal conductivity tests were conducted in an 8-in. guarded hot plate apparatus in a manner similar to that described in Federal Specification LLL-F-32 lb. The specimens, 8 in. by 8 in., were dried in an oven at 140 to 150 F for about 16 hr. prior to test.

For accelerated weathering, the materials were subjected to alternate exposure to a temperature of 150 F in a circulating-air oven and to moisture in a fog chamber at 77 F. The daily schedule included 2 hr. in the fog chamber, 2 hr. in the oven. The test lasted 240 hr.

Flexure tests were made with a self-aligning, adjustable span flexure jig mounted in a universal hydraulic testing machine. The compressive tests were also made on a universal hydraulic testing machine, and special bearing blocks were constructed with brackets to permit using a Southwark-Peters plastics extensometer for deformation measurements.

To summarize, hard rubber had the lowest thermal conductivity of the materials tested; glass and polystyrene changed least in weight and dimensions when subjected to extremes of temperature and humidity; all the organic products were affected to some extent by seven months outdoor exposure, but glass was unaffected; glass and hard rubber, in this order, were least changed in dimension and weight on immersion in various chemicals, all variations being less than 1% except for hard rubber in an aromatic gasoline blend; and balsa was much superior in flexural and compressive properties. (B. M. Axilrod & E. Koenig. *Plastics*, Vol. 5, July 1946, pp. 68-74.)

Sandwich Materials

Condensed from "Aviation"

"DuPont CCA"—cellulose acetate i[n] unoriented multicellular form—is [s]wiched between plywood, metal, or g[lass] cloth faces for use in aircraft. CCA [is] fabricated in various densities betwe[en] and 8 lb. per cu. ft.—each within a [ra]nge of ±0.5 lb.

The product is available as extr[uded] boards, with length limited only by size of container and method of ship[ment]. Width and thickness are limited by nature of the process and capacity of e[xist]ing manufacturing equipment. At pres[ent] widths are 4 to 6 in. and thicknesses to 1 in. Slabs, sheets and blocks can [be] built up from boards by various meth[ods] of gluing.

The core material was first used in se[con]dary and non-structural aircraft applic[ations] because of its uniformity, strength, [and] low density. Its use for primary struc[tures] is now being investigated. Flat, thin la[mi]nates are being tested for use in air[craft] floor panels, bulkheads, furnishings [and] doors. The 4 to 5 lb. per-cu.-ft. CCA [has] sufficient strength for these uses.

Because of the relatively good elec[trical] and thermal insulating properties, [the] material is being used or suggested [for] electrical instrument cases, heating d[ucts] and food-storage cases. Laminated co[re] surfaces are simpler in design than con[ven]tional metal structures. Other applica[tions] are helicopter tail cones and helicop[ter] anti-torque blades.

Machined pieces of any desired sh[ape] can be made from CCA slabs by use [of] standard woodworking equipment. [By] using a gang router to cut a series [of] parallel wedge-shaped grooves ¾ thro[ugh] the material, the core can be shaped with[out] heating by bending it so that the cuts [are] on the inside of the curve.

If the kerfs are properly spaced a[nd] coated with glue, they will close and we[ld] together during the final laminating ope[ra]tion. If the material is carefully heated [to] just below the softening point (400 F) it can be shaped without grooving.

If CCA is squeezed in a cold die, it w[ill] assume permanently the shape of the d[ie]. Standard thermosetting glues are satisfa[c]tory for bonding CCA to itself or to surf[ace] skins.

Tests indicate that a well designed [f]... slab, when subjected to an edge-wise com[]pressive force, will withstand a load equ[al] to 50 to 75% of the ultimate streng[th] of surface skins. Buckling skin stresses [are] 10,000 to 14,000 psi. for papreg-CCA laminates and 20,000 to 28,000 psi. f[or] laminates of glass fiber and CCA. Th...

ENGINEERING DATA ON PLASTICS

6. TRANSFER MOLDING PRESSURES

Test yourself. See if you can answer the following:

Using a pot type mold, how do you calculate pressure and molding area for transfer molding parts?

How would you figure the above, using an auxiliary ram transfer type mold?

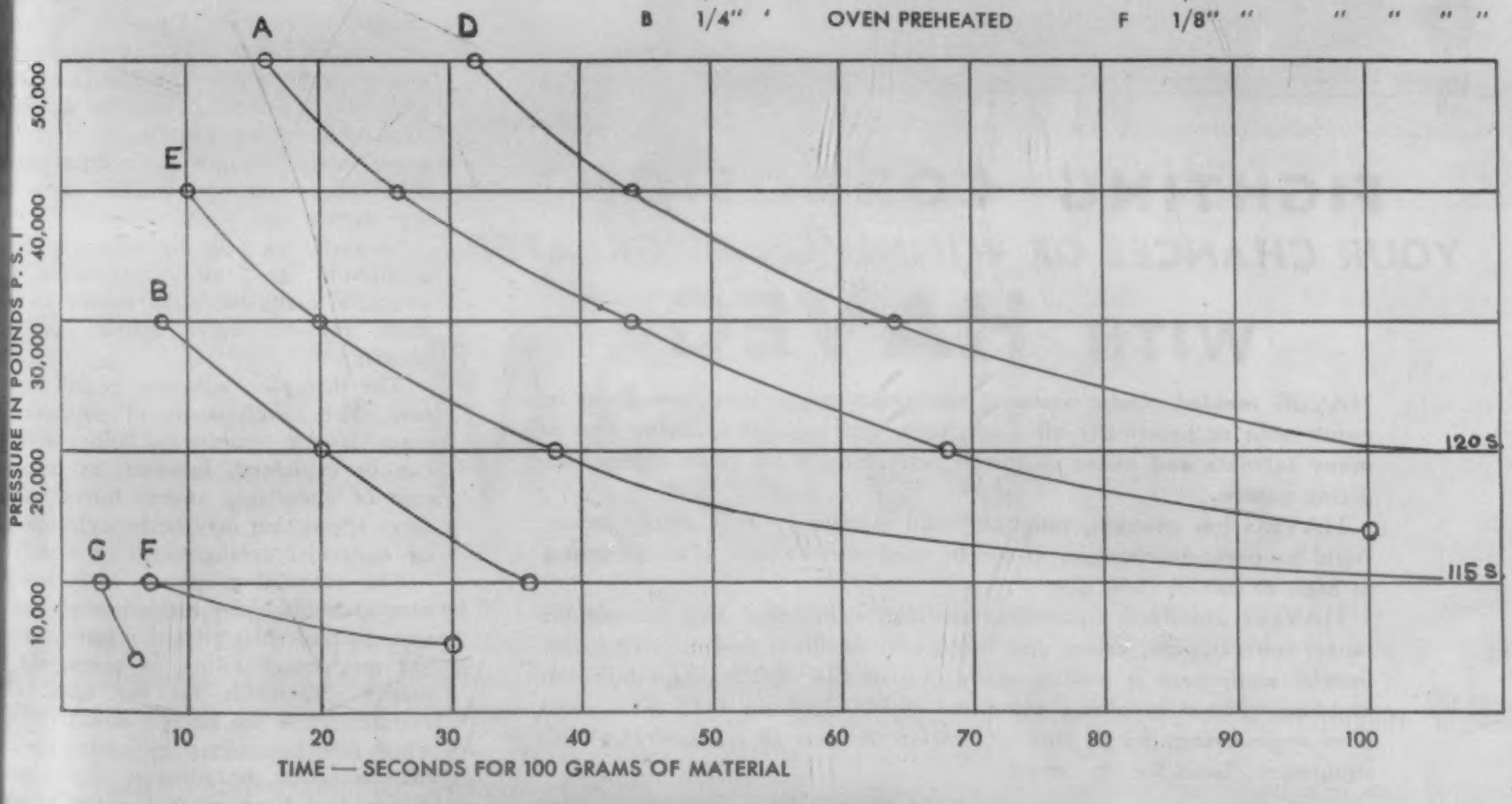
What effect does preheating have on pressures?

When is a one-eighth-inch orifice best? A quarter-inch orifice?

How should gate area compare with runner area?

These questions and many others are fully answered in a new eight-page booklet titled "Transfer Molding Pressures." This free authoritative folder contains a compilation of data recently collected by Durez engineers . . . and includes several practical charts similar to the one shown below. *It is the first printed treatise on this widely discussed subject.* **Write: Durez Plastics & Chemicals, Inc., 910 Walck Road, North Tonawanda, New York.**

TEST	ORIFICE	MATERIAL	TEST	ORIFICE	MATERIAL
A	1/4" DIA.	"AS IS"	E	1/8" DIA.	OVEN PREHEATED
D	1/8" "	" "	G	1/4" "	R. F. " 270° F.
B	1/4" '	OVEN PREHEATED	F	1/8" "	" " " "



DUREZ

PHENOLIC RESINS

MOLDING COMPOUNDS

INDUSTRIAL RESINS

OIL SOLUBLE RESINS

PLASTICS THAT FIT THE JOB

shear strength of CCA is high and ... impact strength is relatively high for ... low-density material. (R. E. Maier. *Avia...* Vol. 45, July 1946, pp. 72-73.)

Adhesives

Condensed from "Steel"

Adhesives are commonly thought of ... substances applied as intermediate lay... between two surfaces to stick these ... each other. This definition is generally ap... plicable, but does not include such a c... as the bonding of fibers in paper; on t... other hand, it does include the solder... of metals, which is not ordinarily thoug... of as being an adhesive application.

Today's adhesives include many sy... thetics. Pure substances are seldom us... Modifying agents find extensive use ... produce desired properties in adhesive co... positions.

Some important applications of adhesi... are in manufacture of plywood, and in t... bonding of metals. The latter found e... tensive use in military aircraft manufactu...

Organic adhesives are finding wide ap... plication in bonding two or more differ... materials. Metal-sheathed plywood is ... example of this type of product. The orga... ics are finding wide usage in instrum... manufacture where mechanical joini... welding or soldering may be difficult ... impossible. Some continuous bonds ha... shown better strength and stiffness quali... than riveted or spot-welded intermitt... type fastenings.

Materials joinable by adhesives inclu... aluminum, steel, zinc, magnesium, ... structural materials, glass, natural and sy... thetic rubbers, wood, textiles, and ma... plastics.

The theory of adhesion is still elem... tary. The development of adhesives ha... been largely empirical. Adhesive for... can be explained, however, by consider... tion of underlying atomic forces, and t... force affects that may be brought into pl... by molecular arrangements of atoms.

The chemical properties of surfaces ... now known to play an important part, ... that the molecular attractive forces, and ... the mechanical filling of pores, are p... marily responsible for the bond. Cl... surfaces retain the highest attractive for... which are neutralized by molecules oth... than those of the adhesive if the surfa... is not kept clean prior to adhesive appl... cation.

Suitable adhesives are now indicated ... considering the proper relationships b... tween the active groups on the adhesi... molecules, and those on the molecules ... the surface. Such considerations are ... indicating the correct adhesive choices ... metal to metal, metal to rubber, etc. bon...

Various standard test methods for ev... uating bond strengths are listed a... described briefly. (*Steel,* Vol. 118, Apr. ... 1946, pp. 100-104, 106, 108 & 110.)

The Charles S. Welsh Memorial Award for outstanding packaging in 1946 to Chen Yu Cloud Silk

Molded

n highly competitive fields the molded plastics container n give merchandise the extra eye appeal that wins nsumer approval. It is a packaging method that offers eatest opportunity for individuality and styling.

The molded container eliminates losses due to breakage transit, and reduces shipping costs because of its ht weight.

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GENERAL PRODUCT DESIGN

Selection, applications and design of parts made by various fabricating methods or made of special materials. Properties and uses of finishes and coatings. Design and materials for specific products or fields. General engineering design trends or principles.

New French Rapid Transit Car

Condensed from "Revue de l'Aluminium"

The "Michelines" are trains equipped with rubber tires. The first train of this type constructed of steel, which went into operation in 1929, was completely satisfactory. From 1929 to 1936 there was a gradual evolution to a 100-passenger car made with a framework of welded steel tubes covered with aluminum alloy panels.

These trains offered the advantages of longer life of the rolling stock and rails, greater comfort due to the elimination of shock and vibration, and better performance because the adherence of the rubber to steel is greater than that of metal to metal, resulting in starting with full power and vigorous braking. However, the resistance to rolling is greater with rubber than with metal tires.

In 1937, due to the electrification of part of the French railways, it became desirable to produce electric trains of this type. The result was the Micheline 136 with 136 seats. Its weight was about a third that of the standard railroad equipment of almost the same capacity. The triangular framework was steel, used in the form of welded shapes and covered with Plymax panels which had a wooden core sheathed on both sides with aluminum sheet.

Most of the coach parts, fittings and "copper work" were made of light alloys, as were many of the auxiliary parts of the motors. A very important lightening of the equipment resulted from the use of stainless steel sheets in place of castings for the starting resistances, of aluminum for the wiring and of modifications of the electric and pneumatic equipment.

The weight saved in the electrical equipment (motors excepted) was about 40% of the normal weight. The cables for the power circuits were made of 99.5% aluminum protected by rigid tubes of U4G aluminum alloy (composition not given).

The weight saving made possible by the use of aluminum for the cables varied, depending upon whether the size was determined by the maximum permissible heating or by the maximum allowable ohmic drop. In the first case, the weight saving was 36%. In the second case, the saving would have been 18% if rubber insulation had been used for the aluminum but actually was 57%, due to the use of a new insulation "lyonisol."

It was found desirable to use copper cable lugs at the ends of the aluminum cables to avoid electrolytic corrosion as well as the increased resistance that would have resulted from the superficial oxidation of the aluminum. Likewise, some of the terminals operated at a temperature too high for aluminum.

A detailed list is given of the various parts made of aluminum, with the French trade names of the grades used. Tests on the only Micheline 136 ever produced showed excellent performance with low current consumption. The war prevented further work on this model.

Work is being done now on new developments and materials. Three trains, one of ordinary steel, one of 18:8 stainless, and one entirely of light alloys, will be constructed for comparative tests. It is believed these new trains will be the most comfortable and modern in the world. (M. Victor. *Revue de l'Aluminium*, Vol. 23, Apr. 1946, pp. 120-128.)

Bearings

Condensed from "Mécanique"

Bearing operation is affected by specific pressure, speed and diameter of the shaft, play in the bearing, viscosity of the oil film, surface finish of the shaft and bearing, nature of the metals, L/D ratio and the oiliness of the lubricant. Three conditions govern the functioning during periods of normal or perfect lubrication: pressure, speed and viscosity of the oil. The other factors affect mainly the boundaries of the normal period.

Various empirical equations are given for determining these relationships. The calculated results are only approximate since many secondary factors are not taken into consideration. The results are simplified by the introduction of the ratio ZN/P where Z = coefficient of viscosity of the oil at the temperature of the oil film; N = revolutions per sec. and P = average pressure.

The active surface (surface covered by the oil film under pressure) corresponds to the length of the bearing minus about 0.8 in. for the pressure decrease at the ends. Anything that decreases the active surface increases the load. The lower half of the bearing, which controls the active surface, should not have any grooves. The upper half may carry a longitudinal groove to feed the oil along the length of the bearing.

The relationship between the coefficient of friction and ZN/P is affected by the viscosity of the oil but not by its oiliness. Within the limits of viscous lubrication the nature of the metal has little effect upon the coefficient of friction. The use of antifriction bearings in place of bronze decreases the critical value of ZN/P and, therefore, increases the zone of perfect lubrication.

When ZN/P approaches the critical value, it is advantageous to replace bronze by antifriction bearings. The use of oil of higher oiliness tends to decrease the critical value of ZN/P. Within the zone of oily but imperfect lubrication, oiliness, viscosity of the lubricant and nature of the metal are important factors in determining the coefficient of friction. The coefficient of friction is not affected by ZN/P but by the layer of oil absorbed by the metal.

The deflection corresponding to the length of the bearing, as calculated from the bending fatigue of the shaft, should not exceed 0.0012 in. The L/D ratio of the bearing is usually 1 to 1.5, and in no case should equal two. The play should be reduced as much as possible. Although a small increase in the coefficient of friction may result, it is largely compensated by the prolongation of the zone of security.

The maximum load is evidently the load which decreases the thickness of the oil film excessively. With current surface finishes, natural cooling and bronze bearings it seems to be about 3.1 to 6.2 psi. for diameters from 1.6 to 3.9 in.

Higher loads can be used with special precautions, such as high viscosity oil, better cooling and improved surface finishes. Speeds for the present bearings are limited by the temperature of the oil film, which should not exceed 175 F.

The maximum eccentricity (ratio of the distance between the center of the shaft and the center of the bearing to the radial play) can be considered 0.5. Various elements, such as surface irregularities and defects of parallelism of the shaft and bearing, will decrease the thickness of the oil film. Bearing standards are proposed based on the extremes of present commercial surface finishes. (P. Martinet. *Mécanique*, Vol. 30, Feb. 1946, pp. 45-52.)

Industrial Design

Condensed from "Modern Plastics"

"Form follows function" has been ac- cepted as an axiom of good modern desig Function encompasses costs, eye or sa appeal, and serviceability. No one design or design staff, can qualify as producti engineer, cost accountant, mechanical e gineer, stylist and sales, distribution a merchandise expert while possessing all t other specialized job skills that are d manded of the team of experts behind mo ern production and distribution.

The industrial designer must at least familiar with the properties of materia tool and die possibilities and limitatio manufacturing processes, principles of m chanics and physics, and methods of d tribution. The manufacturer will then be forced to eliminate repeatedly impra tical but pretty ideas of the designer.

The average industrial designer is n urally strongest in conceiving pleasing for proportion, texture and color combinatio This is his primary contribution to t team of specialists that brings the finishe product to the consumer. Eye appeal ca not compensate for costs that are pr hibitive or for a design that is functiona poor.

The designer should have a practic analytical mind for research and observ tion so that he can perfect sales stimulati and superior function-in-use features up which repeat sales are built. He must d velop utility and convenience, and inco porate them into an attractive design. Th involves a study of economy in motio psychological reactions to form, arrangeme and texture, and ease of handling.

The redesigning of an electric shaver a good example of proper principles. Th die costs for a certain old electric shav housing and the new design are the sa yet many features of utility, eye appeal a serviceability have been added in the su gested design. The product is sold in suf cient quantity to amortize the mold co over a great number of parts, bringing t cost per housing to a negligibly low figur

The plastic core is more compact a lighter than the old metal and fabric bo making for cheaper shipment by the pr ducer and easier handling by the user. Th rapid stowage of the electric cord in t carton while it is still attached to the shav housing is an important feature.

In the old model there were six ste which proved onerous to the user: Remo ing the cord from the carton and diseng ing the cord from its holder; unwindi the cord and inserting the female pl into the shaver housing; inserting the ma plug at the power source and removal up completion of the shave; disengaging t rubber female plug from the shaver; r placing the shaver and rewinding and r stowing the electric cord.

The design of the new model reduc these six steps to the single action of plu ging the unit into the power source. Th electric cord and plug are a semi-perm nent integral part of the housing; yet t cord can be easily replaced should it b come worn out or broken. (Gerald Sc *Mod. Plastics,* Vol. 23, July 1946, pp. 10 110.)

MELTING and CASTING

Melting, alloying, refining and casting methods, furnaces and machines. Iron and steel making, nonferrous metal production, foundry practice and equipment. Die casting, permanent mold casting, precision casting, etc. Refractories, control equipment and accessories for melting furnaces.

Vacuum Permanent Mold Casting

Condensed from "The Foundry"

The vacuum-casting system was originated by M. Bruneau in Paris and found widespread application in Europe during the war for making cylinder-heads of internal-combustion engines. The theory of the process is to evacuate the section of the mold that has a thin area, which allows atmospheric pressure to force the molten alloy into the cavity. Castings with sections as thin as 0.03 in. are cast successfully.

An example of the use of the system is a 6½-in.-dia.-bore engine. The combustion space and exhaust passages are formed by sand cores. The casting is made with the rocker faces downward and the combustion space facing up. The metal is introduced through the center area. This core is hung downward. The metal flows down through the center on to the guide-valve bosses which are solid, and then into the thin area and back up around the cylinder-barrel face, which is extended and has two risers.

There is a feed to the absolute center of the head. These cylinder-heads were very satisfactory, as metal was fed to the right place in the right quantity and at the same time allowed progressive solidification, the outside solidifying first and the center feeder feeding into the highly stressed areas until the feeding cycle was completed.

The lower nine fins were larger than the balance and have the fin sections made in four separate blocks, parting at 90 deg. The series of fins which received the direct flow of metal plus the full effect of the weight of metal required a vacuum of only 7 lb., while the large fins higher up in the mold required a complete vacuum to make them fill satisfactorily.

These fins were 0.03-in. thick at the tip, with 1-deg. taper. This required 2 deg. of vacuum. To obtain this, a single central vacuum pump was used and tapped into large capacity storage tanks with various degrees of vacuum. These tanks were piped and controlled by stop-valves and attached to cover-plates on the exterior of the mold, sealing the heads of the cores forming the cylinder fins.

Adaptations and improvements were made for other types of cylinder-heads, and the system was applied to many other jobs, thereby eliminating the human element. The prime feature of the process is to produce a casting that is impractical under any other means.

Cost of mold manufacture is high. Great skill is required in machining, and all parts must be fitted most accurately. The breaking in of these tools has a very great bearing on their ultimate life. Trained personnel is required to handle the equipment if its life is to be sufficient to justify the capital investment.

If the castings do not weigh less than 4 lb., they should sell for 38 to 42¢ per lb. (Jack W. Wheeler. *Foundry,* Vol. 74, June 1946, pp. 90-93, 268, 270.)

Developments in Gray Iron and Malleable

Condensed from "Metal Progress"

Judged by the output in tons, the gray iron foundry forms the largest branch of the ferrous casting industry. This in itself indicates the vital part gray iron played in war. When it is further realized that not many years ago an iron of about 40,000 psi. was considered a high-test iron, whereas today considerable tonnages are produced testing as high as 70,000 and 80,000 psi. in tension, it is evident that its usefulness as an engineering material has been greatly increased.

Extensive studies of cupola operation have resulted in greatly improved metallurgical control and a better understanding of the detrimental effect on the iron of certain products of combustion. It has been found, in particular, that excessive amounts of hydrogen when present in the structure of iron have a pronounced embrittling effect; hydrogen increases the carbide stability, tends to produce chill spots and to promote porosity.

When moisture enters the cupola with the air and immediately strikes the white hot coke it is decomposed into hydrogen and oxygen. This absorbs heat—has a chilling effect. Likewise, the hydrogen being mainly in the nascent state, is exceedingly active in its action on the hot iron it meets.

In addition to moisture control units in the iron foundry, a development of considerable interest and promise is the basic lined cupola. Use of a basic cupola will reduce the 0.12% phosphorus and the 0.07% sulphur (normal for gray iron) down to 0.03% maximum for each element.

The effect of inoculants of the graphitizing group (which consist of strong graphitizers such as silicon-calcium-titanium alloys, silicon-nickel alloys, or silicon carbide) is to produce fine graphite nuclei in the molten metal which promote the formation of the random type graphite. Due to the large number of nuclei formed, the graphite flakes are of moderate size and are of uniform distribution.

In comparison with irons with coarse graphite flakes, fine graphite increases the tensile strength as well as transverse deflection without appreciably increasing the hardness. Freedom from dendrytic type of graphite, furthermore, increases the resistance to wear.

As shrinkage is a direct function of percentage of combined carbon, the effect of the inoculants in reducing the chilling tendency also results in increased soundness and uniformity of structure (and hardness) —all of which are of particular importance in castings with varying cross sections.

During the war large diesel engine crankshafts for submarines, cargo ships and landing craft were made of cast iron. These crankshafts have set up an excellent record for service. Great savings in material and machining have also been effected, which is best evidenced by comparing the block forged crankshaft for an 8-cylinder marine diesel engine which weighed 36,000 lb. in the rough and 12,000 lb. finished machined, with the casting used in place of it which weighs only 14,000 lb. in the rough—a substantial saving in both material and machining time. Analysis of this crankshaft was 2.65% total carbon, 2.48% silicon, 1.18% manganese, 1.21% nickel, 0.17% chromium and 1.15% molybdenum.

The malleable industry, which in 1944 produced something over a million tons of castings, has also made rapid advances both through metallurgical research and through extensive mechanization and modernization in both old and new facilities.

The metallurgical trend in the malleable industry has been toward much lower carbon content. This improves the physical properties and opens a much wider field of application—best evidenced by the very large malleable castings used in mechanized ordnance in heavy rear axle housings for trucks, and gun bases weighing 300 to 400 lb. and having sections as much as 4 in. thick. (G. Vennerholm. *Metal Progress,* Vol. 49, June 1946, pp. 1163-1168.)

Influence of Tellurium as a Chill-Inducing Medium in Cast Iron

Condensed from "The Foundry Trade Journal"

Three methods of introducing telluri into the iron were investigated: (1) As direct addition to the ladle; (2) as a m wash or lacquer; and (3) mixed w facing sand. Rough standardization was tained by using a pattern 8 in. by 4 in. 2 in. for the test blocks.

When added to the ladle, a powd ranging from 0.001 to 0.02 was used. Th powder was scattered loosely over the bo tom of the ladle and the molten iron tappe or poured on to it. In practically eve case the bulk of tellurium was, due to low volatization point, immediately lo with the production of clouds of fumes.

In view of the erratic results and of th irritant effect of the fumes evolved, the ad dition of the loose powder was discontinued and a means of protected addition was trie This consisted of enclosing the powder thin copper foil, or in copper tubes, close at the ends.

An immediate improvement in result wa effected and fractures ranging from com pletely white, through varying depths o chill to mottled and gray, were obtained a random in the test blocks. Here again however, the results were erratic, due, was considered, to the tendency (whe using low-temperature iron) of the copp capsule to float and only partially dissolv From this, the melting point of copper wa considered to be too high, and aluminum foil and tubes were substituted.

When used as a mold wash, differen percentages by weight of tellurium powde were tried, ranging from 1 to 20. It wa found that 10% imparted the deepest chill The most satisfactory results were obtained when mixing tellurium powder with a ordinary foundry blackwash. The hotte and more fluid the iron, the greater was th chill obtained, up to an apparent maximum of ⅛-in. being obtained by this means.

The application of tellurium mixed wi ordinary green facing sand is of a particula importance where the lacquer cannot readily be applied. Here again 10% was found t be the maximum necessary to give the ap parently greatest depth of chill obtainable by this means. (*Foundry Trade J.*, Vol. 78, Mar. 14, 1946, pp. 283-287.)

The "Elkem" Rotating Arc Furnace

Condensed from a Paper of The Electrochemical Society

It is well known that ferro-alloy furnaces and other electric melting furnaces, operat ing at high temperatures, will in time de velop craters which result in a less efficient operation of the furnace. These craters in evitably lead to uneconomical and difficult operation.

The furnace gasses cannot penetrate the crater walls, and accordingly have to force their way along the surface of the electrodes to the top of the furnace. The gasses thus become overheated and leave the furnace at an unusually high temperature, and will

often, with great violence, break through the slag covering at certain spots and, simultaneously, fine white flames of evaporated metals will appear. In this way serious losses of material from the furnace may result, due not only to evaporation of the constituents of the charge but also due to dust caused by the violent escape of gas. Consequently, there may also be large losses of heat from the furnace. The hot gases will overheat the electrode sections outside the furnace so that the wear and tear on the electrode holders will be very serious.

In Norway there has been developed a rotating electric melting furnace, the "Elkem Rotary Furnace", which effectively eliminates the formation of craters. Ordinarily this furnace is designed as a three-phase furnace with the electrodes suspended at the three points of an equilateral triangle. The furnace pot is round and rotates or oscillates slowly, so that the melting zones constantly move sideways relative to the electrodes. By this rotation the whole furnace charge is successively drawn into the melting zone, and the furnace bowl is kept clean and free from craters.

Development work on this project began in 1917 but was not considered ready for trial on a full commercial scale until 1937. At this time there was put in operation a 7000-kw. furnace of 190 tons weight on the turntable. This initial furnace proved so satisfactory that another has been constructed and two more are in process of construction at this time.

At Porsgrunn Elektrometallurgiske in Norway an Elkem furnace and an ordinary non-rotating furnace were operated simultaneously, producing 75% ferro-silicon with the same class of raw materials. The results showed that the Elkem furnace had about 17% larger production with the same consumption of power and the consumption of materials per ton of ferro-silicon produced was about 10% less.

The operating and maintenance costs for the rotary equipment are almost nil. The erection costs for the Elkem furnace is only about 8% greater than that of the ordinary electric furnace, including the transformer but not the buildings and other equipment. (Tonnes Ellefsen. *Electrochemical Soc.*, Preprint No. 89-12.)

Preventing Gas in Light Metals

Condensed from "Aluminium"

Often strong swellings have been observed near the welding seam of light metals, in particular of aluminum-magnesium alloys with high magnesium contents, which must be ascribed to gas content of the alloy which could not escape any more after solidification of the aluminum solid solutions.

By taking care that in producing the alloy a residual part of the melt remains which solidifies at a much lower temperature than the solid solutions, the gases are given an opportunity to escape from the still pasty mass. This method does not impair the good surface corrosion properties of aluminum-magnesium alloys, and improves the stress-corrosion behavior. (H. Mäder. *Aluminium,* Vol. 26, May-June 1944, pp. 83-84.)

FABRICATION and TREATMENT

Machining, forging, forming, heat treating and heating, welding and joining, cleaning and finishing of solid materials. Methods, equipment, auxiliaries and control instruments for processing metals and nonmetals and for product fabrication.

Gas Carburizing

Condensed from a Paper of the Iron and Steel Institute

The mechanism of carburization in solid and in gaseous media is discussed with reference to the action on 0.15% carbon case hardening steel, 3% nickel case hardening steel, and nickel chromium case hardening steel. The carburizing properties of two types of atmospheres, namely, the hydrocarbon-rich type and that containing little or no hydrocarbon gas and approximating the atmosphere which is found in a pack carburizing box, were investigated.

The hydrocarbon-containing gases have included town gas, butane, and propane, and a study has been made of the effect of diluting these gases with inert or decarburizing agents for the purpose of reducing sooting of the work, while maintaining a high rate of carburization. The carburizing atmospheres not containing hydrocarbons were specially prepared in typical industrial controlled-atmosphere units. The carburizing temperature selected was, in the majority of tests, typical of industrial practice for the steel in question.

The degree of carburization was determined in a number of ways: (1) By measurement of the increase in weight of the steel per unit area of surface; (2) by chemical determination of the carbon content of the marginal layers of the carburized steel; (3) by metallographic estimation of the case depth; and (4) by depth-hardness measurements on the quench-hardened carburized steel.

Investigation of the carburizing properties of raw hydrocarbon gases such as town gases and butane has indicated that the ready deposition of soot from both gases interferes with the carburization reaction and, in extreme cases, can completely inhibit carburization. Town gas contains decarburizing gases which offset to a large extent the carburizing constituents. The processing of town gas in order to eliminate the unsaturated hydrocarbons and the decarburizing gases results in an atmosphere being obtained which is strongly carburizing, although the tendency to sooting is not completely eliminated.

Diluting agents such as air and burned town gas call for high concentration of propane to offset the decarburizing gases present. To obtain anything approaching a maximum rate of carburization, propane contents above 25% have to be considered, with the result that the tendency to sooting is considerably increased. It has not been found possible, when using either air or burned town gas as a diluting agent, to eliminate sooting and still to maintain the maximum carburizing rate.

A diluting agent which contains no decarburizing gases can be generated by the treatment of burned town gas over charcoal at approximately 1000 C. Carbon dioxide and water vapor can be completely removed by reactions with the charcoal, and the resulting gas is itself carburizing. Concentrations of propane of the order of only about 2% are sufficient to make the atmosphere very strongly carburizing, and because of the low concentration of the hydrocarbon gas a maximum rate of carburization without sooting can be obtained.

The carburizing properties of carbon-monoxide-hydrogen atmospheres, prepared from town gas, charcoal, or both, have also been investigated. The atmosphere generated by the treatment of rich town gas air mixtures over charcoal maintained at a temperature sufficiently high to eliminate carbon dioxide and water vapor, has excellent carburizing properties.

The addition of a small concentration of propane safeguards against any trace of decarburizing gas that may remain in the generated atmosphere, and results in a maximum rate of carburization without sooting. As distinct from the diluted propane atmosphere, which tends to produce a hypereutectoid case with a deep cementitic network, the carbon-monoxide-hydrogen type of atmosphere produces a surface near to the eutectoid composition, with a case of rather less depth. However, the need for a diffusion period to remove the cementitic network is avoided.

The effect of the steel surface upon the rate of absorption of carbon by a steel has been investigated. Roughening the surface by heating the steel in an atmosphere in which inter-gas reactions are promoted by the steel markedly increases the activity of the surface and speeds up the rate of carburization.

For carburization to proceed at a satisfactory rate, it is necessary for the steel to be in a condition which readily absorbs the nascent carbon supplied to it at the surface. The foregoing experiments have shown that below the upper critical point for the steel, *i.e.,* in the ferrite austenite phase, the rate of solution of carbon by the iron is comparatively slow. Gamma-iron, on the other hand, dissolves carbon very readily, and the cementation process is invariably carried out above the upper critical point for the steel.

When a carbon steel is treated at a suitable high temperature in an atmosphere containing carbon dioxide, direct reaction may take place between this gas and the carbon in the steel.

If the carbon monoxide is in excess of that required for equilibrium in this reaction, the steel is carburized. Under certain conditions, however, it is also possible for the carbon monoxide to deposit on the steel surface free carbon which does not enter into solution in the iron.

In such a case an atmosphere which is balanced with respect to cementite in the steel contains excess of carbon monoxide with respect to equilibrium with solid carbon, and sooting may result from the progress of the producer-gas reaction to equilibrium. If the atmosphere is balanced with respect to reaction, however, decarburization of the steel will take place. An atmosphere having a composition intermediate between the two sets of equilibrium concentrations can therefore lead to both sooting and carburization. (Ivor Jenkins. Paper, *Iron & Steel Inst.* June 1946, 21 pp.)

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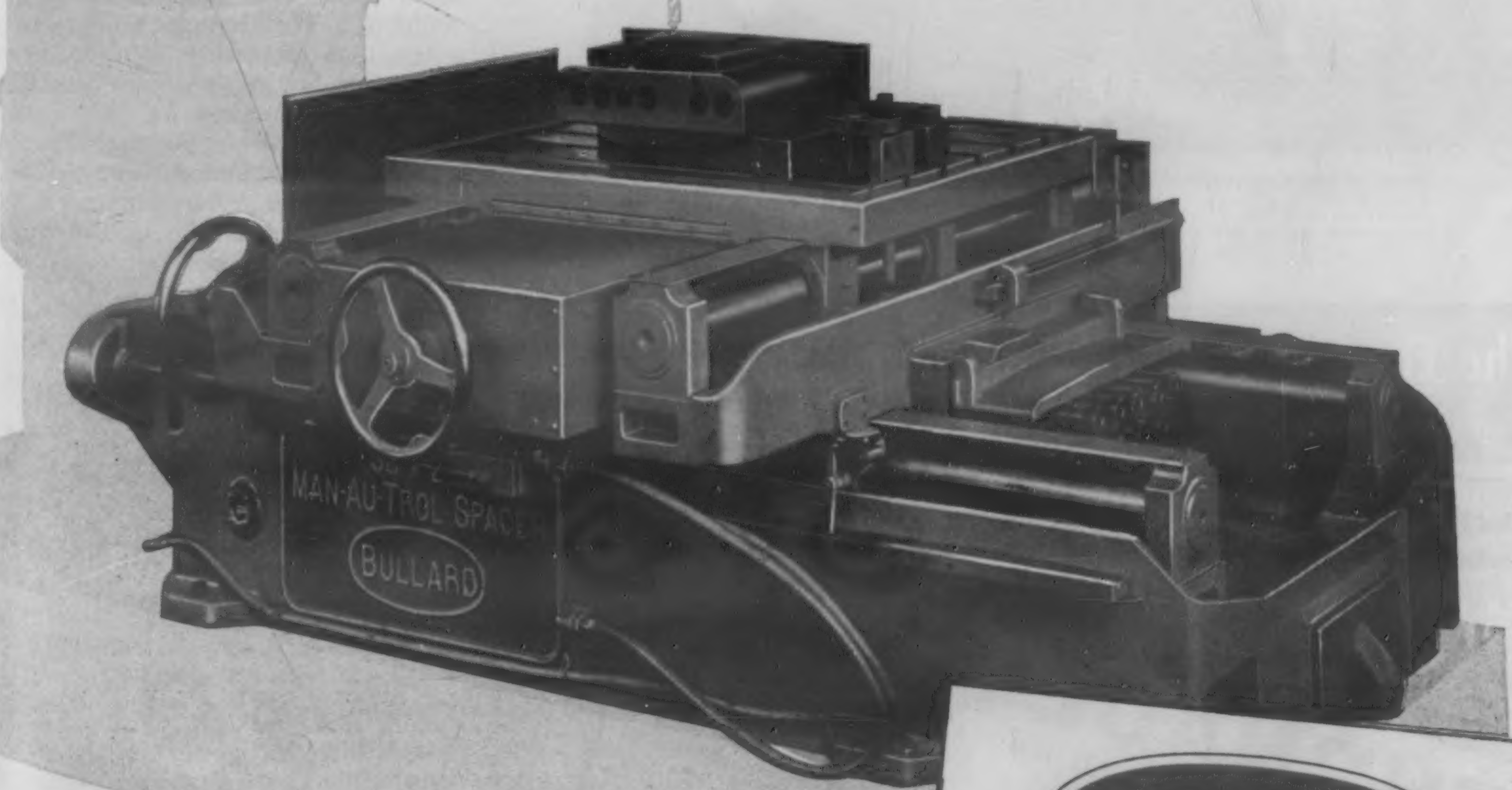

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CREATES *NEW METHODS* TO MAKE MACHINES DO MORE

Corrosion Resistant Finishes

Condensed from "Metal Industry"

Surface conversion coatings are formed by chemical modifications of metallic surfaces, in order to secure greater resistance to high humidity, corrosive atmosphere, or high temperature. In most cases the resultant finish is an oxide or at least an oxidation product.

Copper and brass are treated in several ways to produce a black finish. The cupric oxide finish can be obtained by oxidation in a sodium carbonate-ammonium hydroxide and copper carbonate solution. The copper sulphide finish is produced in a sodium sulphide solution operated at room temperature.

Anodic oxidation of aluminum alloys is performed in a number of different electrolytes, as, for example, sulphuric acid, chromic acid, oxalic acid or boric acid. Processes utilizing these chemicals are divided into three general classes: first, those in which the electrolyte has little or no solvent action on the coating that is formed; second, those in which the electrolyte exerts an appreciable solvent action on the coating; and third, those in which the electrolyte tends to dissolve the coating about as rapidly as it is formed.

Conversion coatings on magnesium are radically different from those produced on aluminum, since these coatings are sparingly soluble in water, and their solubility increases some 50 times in water containing carbon dioxide.

In the case of aluminum, the oxide is quite insoluble in water or weakly acidic solutions. The formation of protective coatings on magnesium by chemical treatment has become almost universal, but recently a new process for anodizing magnesium has come into popularity.

The war has brought into widespread use surface conversion coatings for zinc, cadmium and their alloys. The chromate finishes on zinc and cadmium give increased corrosion resistance, as do the phosphate coatings which have recently come into the foreground. Both make for better paint adhesion. (G. W. Jernstedt. *Metal Industry*, Vol. 68, May 25, 1946, pp. 407-409.)

Control of Pickling Baths for Stainless

Condensed from "Steel"

Hydrofluoric-nitric acid pickle bath is finding increasing use in the pickling of various stainless steels, and is especially valuable for cleaning siliceous welding flux residue and scale from stainless steel parts after welding or annealing.

Baths as made up contain approximately 1% anhydrous hydrofluoric acid and 12% anhydrous nitric acid by weight. Proper bath control requires determination of total acid, as well as iron, fluoride, and nitrate ions.

For room temperature operation, the following conditions should be maintained: Total acid—0.15 to 0.35 equivalent, nitrate ion—7.5 to 20.0 grams/100 ml. of sample, molar ratio fluoride to iron—about 6 to 1.

Total acid and nitrate ion concentrations are not critical if kept approximately within the above limits. Absolute amounts of iron and fluoride present in pickle bath also are not critical up to at least 3 grams of iron and 6 grams of fluoride per 100 ml. of sample, even though ratio of concentrations has some effect on pickling rate.

Because of the fairly wide range of allowable concentration, accuracy obtained by methods of analysis described here is more than sufficient. It is believed that this method is a worthwhile contribution to more efficient operation of stainless steel pickling solutions by practical analytical control. (*Steel,* Vol. 118, June 10, 1946, pp. 110-112.)

Welded Locomotive Boilers

Condensed from "Mechanical Engineering"

On March 11, 1936, after a preliminary cooperative study with the American Locomotive Co. covering a period of five years, The Delaware & Hudson Railroad Corp. obtained the approval of the Interstate Commerce Commission to purchase from the American Locomotive Co., for the purpose primarily of experimentation, one fusion-welded locomotive boiler. This boiler, the first of its type to be used in a locomotive, was presumed to possess certain improvements as follows, in comparison with the riveted type: (1) Reduction to a minimum of caustic embrittlement; (2) smooth interior surface, permitting maintenance of a clean boiler; (3) pitting dangers reduced; (4) weight reduction; and (5) elimination of concentrated stresses in rivet zone, etc.

The boiler was built at the Dunkirk, N. Y., plant of the American Locomotive Co., welded seams being examined for defects by X-ray. After completion and assembly of the shell and outside firebox, it was shipped to the Combustion Engineering Co., Chattanooga, Tenn., for stress relieving, being placed in a furnace and the temperature gradually brought up to 1100 to 1150 F, held for 2½ hr., and then furnace cooled.

Before the boiler shell was placed in the furnace, the firebox ring was bolted in place as a stiffening member, and the flat and circular parts of the wrapper sheet were thoroughly braced to prevent distortion. The stress-relieving was accomplished without any measurable change in contour.

The boiler was then sent to the Schenectady plant of the American Locomotive Co. where the inside firebox and tubes were applied. After completion, the fusion-welded boiler was subjected to hydrostatic test of 1½ times the maximum allowable working pressure and, while subjected to this pressure, was given a thorough hammer and impact test, following which the pressure was raised to not less than 2 times the maximum allowable working pressure and held for a sufficient length of time to enable inspection to be made of all joints and connections. Finally, an inspector entered the boiler and the interior surfaces and connections were examined thoroughly.

The boiler was shipped from the builders plant to the Delaware & Hudson Co. shops at Colonie, N. Y., where it was used as a

stationary boiler without lagging and jacket for a period of 6 weeks for observation and check before mounting as a locomotive boiler.

At the conclusion of this six-week period, the boiler was mounted and the locomotive was placed in service subject to boiler inspections, tests, and reports as follows for the first five years:

In the first year, the lagging and the jacket were removed and shell joints examined each 3 months.

In the second year, the same procedure obtained each 6 months, and yearly thereafter up to 5 years service.

It was also required that when the hydrostatic test was applied the pressure should not be less than 1½ times the maximum allowable working pressure.

At the time this locomotive was shopped in 1943, after 6 years service, a new firebox tube sheet and new firebox throat sheet were applied after 304,956 miles. It is of interest to note that a check of seventeen other locomotives of the same class showed these sheets were renewed at an average of 193,000 miles. No work has been done on the shell portion of the welded boiler as none has been found necessary after approximately 378,000 miles of service.

In locomotive boiler construction welded seams having a tensile strength and elongation equal to or better than the parent metal are required and are obtained by following the Welding Procedure given in Section 9 of the A.S.M.E. Boiler Code rules. In so far as possible, down-position welding is arranged for, and the smothered-arc type of machine welding is extensively employed.

With the ending of the war a number of orders have been placed for welded locomotive boilers, and additional orders are pending. When these welded boilers are ordered in sufficiently large quantities to justify the maximum employment of positioning devices and the maximum use of machine welding, the cost of these superior boilers will be reduced to a point where it will compare favorably with the cost of riveted boilers.

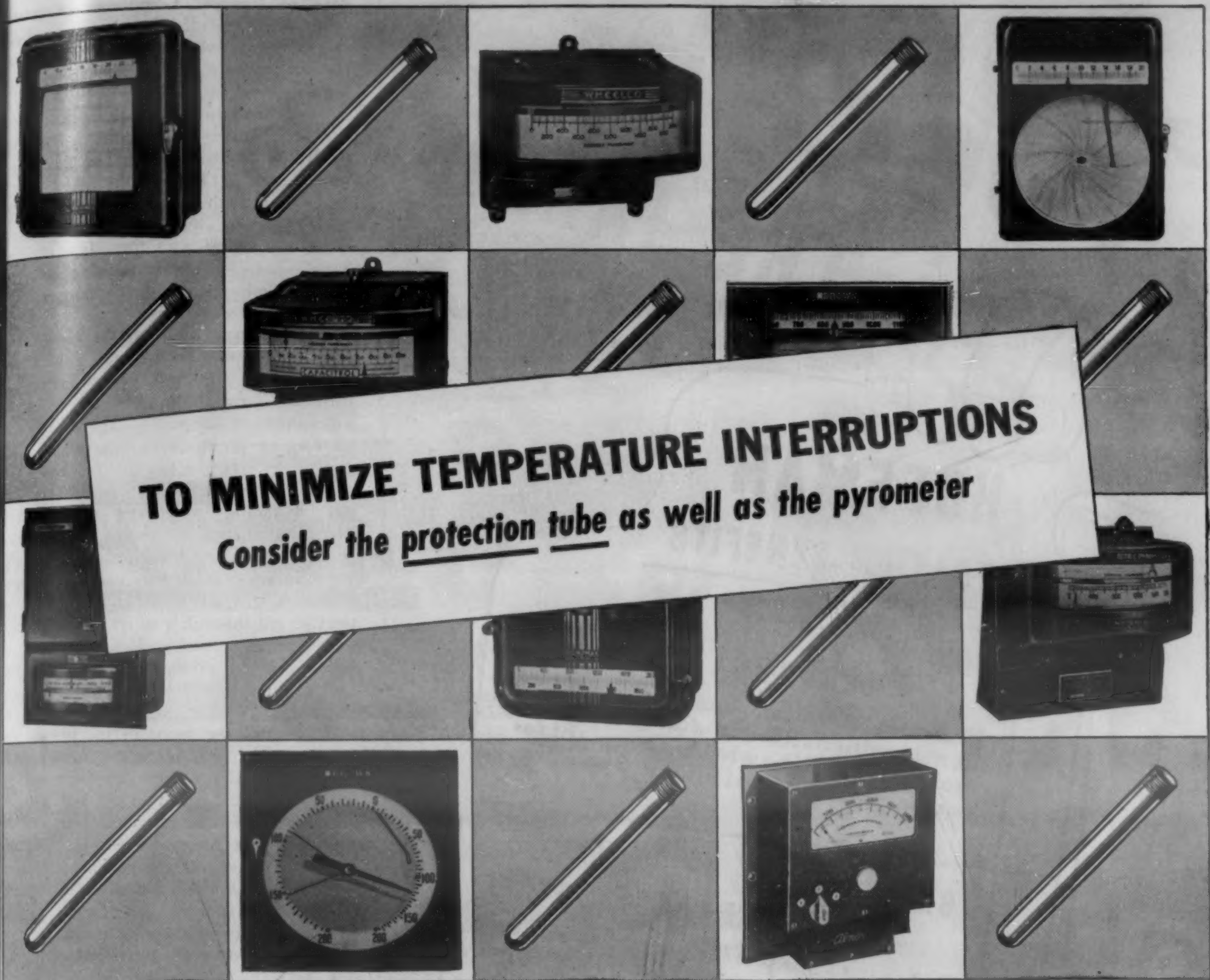
The use of welded locomotive boilers will greatly reduce the charges for boiler maintenance in railroad shops and also greatly reduce the time that locomotives are out of service for boiler repairs. (G. S. Edmonds, James Partington & John M. Hall. *Mech. Engineering*, Vol. 68, July 1946, pp. 619-624.)

Shell Forgings

Condensed from "Iron and Steel Engineer"

A process used by the Tennessee Coal, Iron & Railroad Co. is described. Billets used were 6-in. square, with ⅜-in. round corners, weighing about 10 lb. per lineal in. An automatic, multiple, oxyacetylene-torch nicking machine was developed for nicking the billets—at first on two opposite sides, later on only one side. A 1200-ton crank-press was fitted with suitable dies and fixtures to break the nicked billets into slugs about 12⅜-in. long, weighing about 124 lb.

The slugs were heated in a doughnut-type rotary-hearth, automatically controlled,



TO MINIMIZE TEMPERATURE INTERRUPTIONS

Consider the protection tube as well as the pyrometer

Let's assume you've bought a pyrometer. Cost—$350.

That's a lot of money, but you're glad to pay it for reliable temperature indications.

Now, let's consider the other end of your set-up . . . the thermocouple. *The most expensive pyrometer can be no more reliable than its thermocouple!*

If that thermocouple is inadequately protected against corrosion, embrittling atmospheres and mechanical shock, out goes all the dependability you bought with your $350.

Yet, every day hundreds of thermocouples *do* fail because their protection tubes do not stand up.

Today, almost a score of metals and materials are used as sheathing for thermocouples. Many are not suited to the temperatures and conditions encountered in modern processing operations.

In recent years, however, a new metal has been developed with greatly improved serviceability. That metal is Inconel. It combines strength and all-'round corrosion resistance with unmatched thermal endurance.

Because of its resulting longer life, an Inconel protection tube actually costs less in the long run than the tubes you're now using.

Investigate long-lived Inconel. With Inconel protection tubes on the job, you can be sure of minimum interruptions in temperature measurements.

Seamless drawn Inconel protection tubes are available in standard diameters, with one end closed and the other end threaded. YOUR REGULAR SUPPLIER OR INSTRUMENT MANUFACTURER can furnish any size in any length with either standard or extra-heavy wall thickness.

THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall Street, New York 5, N. Y.

YOU SOLVE 5 PROBLEMS WHEN YOU USE INCONEL*

HIGH TEMPERATURES!

You can use Inconel tubes up to 2200° F. in sulfur-free atmospheres. And at any temperature, their thinner, drawn walls give you quicker, more accurate response to temperature changes.

CORROSION!

Inconel resists chemical attack by carburizing vapors and gases . . . nitriding atmospheres . . . fused salt baths.

MECHANICAL SHOCK!

Inconel retains its strength and toughness at high temperatures. Takes plenty of rough handling.

REDUCING ATMOSPHERES!

Inconel is not embrittled by the reducing atmospheres used in bright annealing, nitriding, oxide reduction, etc.

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Inconel resists scaling—even at high heat.

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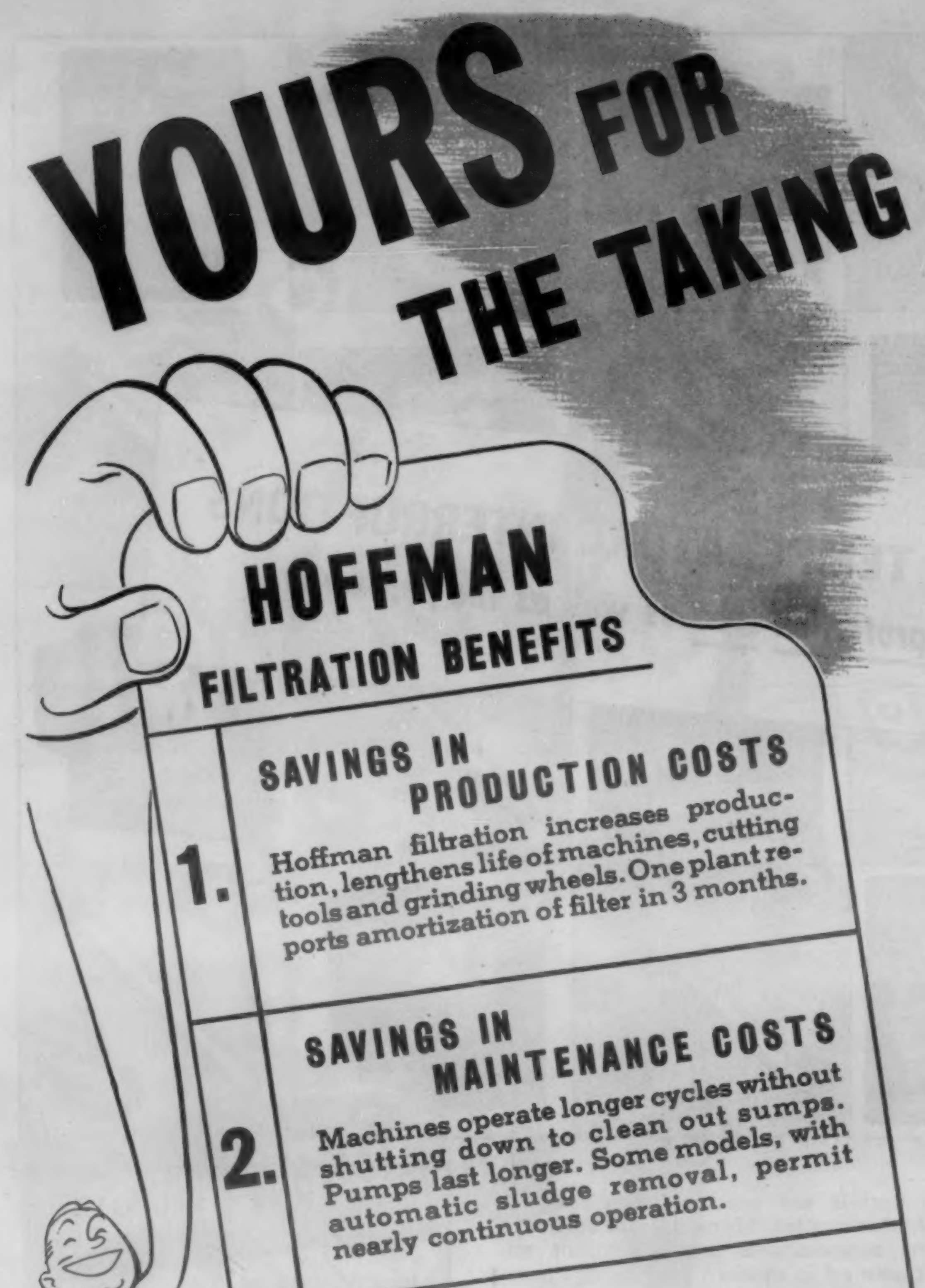
INCONEL ...for long life at high temperatures

(80 NICKEL–14 CHROMIUM)



gas-fired furnace. Compressed-air-operated tongs were provided for charging and discharging the furnace. The control valves for the furnace doors were also on the tongs.

The temperatures for each zone were controlled separately and maintained at 2000 to 2100 F for zone 1, 2300 to 2350 F for zone 2, and 2350 to 2400 F for zone 3. Slugs were discharged at 2250 F. Capacity of hearth was 280 slugs on end in rows across the hearth with four slugs per row. Speed varied from one revolution in 1.7 hr. to one revolution in 3.3 hr. Average heating rate was 150 slugs per hr.

Heated slugs were carried by a chain conveyor through an hydraulic descaler and to a 320 to 400 ton vertical turret-type hydraulic piercing press, where the bottle was formed in one stroke. The descaler and all forging presses were operated at 2500 psi.

The bottles were drawn on 100- to 140-ton hydraulic roller-type draw-benches. Mandrels, shaped to provide the required contour and size of cavities in the shells, were inserted into the partially formed cavities. The mandrels and bottles were then forced through a series of passes, each consisting of three rollers, assembled in housings. The proper draft for each pass was accomplished by varying the dimensions of the rollers.

To control the shape of the fins on the forgings, the rollers were machined to provide proper contours. To overcome objectionable fins formed in the last pass, an auxiliary pass was provided between the third and last passes. The rollers in this pass were set to roll grooves in the forgings at the locations where fins would be formed at the last pass.

The forgings were cooled on an inclosed pitch-chain conveyor provided with cast iron pegs on which the forgings rested. They were cooled slowly to about 900 to 1000 F, then more rapidly by means of forced air to 400 to 600 F. Finally, water-cooling sprays were used.

Before a heat was released for forgings it had to meet the ladle and check analysis specifications, pass nine etch tests, and test shells had to meet the specifications for mechanical properties. The finished forgings were required to pass a number of visual and gage inspections.

The tool steel giving the best results for punch tips contained 8 to 10% chromium, 0.30 to 0.60% manganese, 0.25 to 0.35% carbon, 1 to 1.30% silicon, 1 to 1.25% molybdenum, 0.03% sulphur maximum, and 0.25% phosphorus maximum. For punch shanks and mandrels, composition was 4 to 6% chromium, 0.40 to 0.60% manganese, 0.15% carbon maximum, 0.40 to 0.65% molybdenum, and low phosphorus and sulphur. Knock-out pins and die pot liners contained 0.50 to 0.75% chromium, 0.70 to 0.80% carbon, 0.30% manganese maximum, 0.15 to 0.30% silicon, 0.03% sulphur maximum, and 0.025% phosphorus maximum.

The draw bench rollers were of chilled cast-iron containing 1.35% combined carbon, 2.04% graphite, 1% nickel, 1.50% silicon, 1.50% chromium, and low sulphur and phosphorus. (W. F. Jones: *Iron & Steel Engr.*, Vol. 23, July 1946, pp. 92-100.)

Welded Destroyers

Condensed from "The Welder"

This article deals with prefabricated destroyers built by J. Samuel White & Co., Ltd., for the British Admiralty. The fabricated units were to be as complete as possible, weighing 8 to 10 tons, and not exceeding 40 ft. in length.

An arrangement of prefabricated panels was developed, and for the initial vessels scale models were prepared showing the complete system of panels, prefabrication, etc. A further set of detailed drawings was prepared showing the welding procedure for all items. Standard tables were prepared giving all types of edge preparation, sizes of rods, etc., to suit thicknesses of plates. Flush butt joints were adopted.

The fabricating shops were divided into four principal bays, about 250 by 40 ft., served by a series of 5-ton overhead cranes. Shops having an outlet to an outside area are spanned by an 8-ton Monotower crane.

A substation in the shop supplies all welding equipment, which is standard a.c., so arranged that eight transformers, with a capacity of 70 to 80 welders, can be employed simultaneously. There are also automatic welding machines and various types of flame-cutting equipment.

Building berths are arranged so that all portions can be served by at least one 8-ton crane. There are six transformers, fed from the main substation, so arranged that a maximum of 50 to 60 welders can be employed on any one berth. Arrangements have been made at each berth for the operation of the largest type Unionmelt machine.

Two transformers are provided at fitting-out wharfs, and 20 to 30 welders can be employed simultaneously on vessels afloat.

The main welding-shop bays are allocated to specific items. Generally, decks are used as the base, the units being built upside down, and turned as necessary to allow downhand welding, thereafter being subdivided for transport, if required.

The midship portion is completed in the shop with its requisite shell, longitudinals, floors, etc., and lifted as a complete unit. End units are completed, brought from shops, and erected. Special insert plates are fitted in way of inlets and outlets to obviate use of doublers, etc. At launch the vessel is 95% structurally complete, excluding loose work.

To determine correct procedure, actual test-pieces are made up and welded under working conditions, subjected to hardness tests, etched, sulphur printed, and tested for tensile and other properties. During construction, an extensive number of welds throughout the vessel are examined radiographically, sections also being cut out by trepanning for examination.

Experience with various vessels indicates that prefabrication is the preferable method; the structure should be completed in as long lengths and volumes as practicable in shops; at least 75% of the welding should be done in shops; procedure, sizes of electrodes, and preparation of edges should be followed rigorously; sizes of welds should be reduced to a minimum consistent with strength; and intermittent welding used wherever possible. (*Welder*, Vol. 15, Jan.-Mar. 1946, pp. 1-8.)

TESTING and INSPECTION

Testing methods and equipment for physical and mechanical properties, surface behavior and special characteristics. Radiographic, spectrographic, identification, metallographic, dimensional and surface inspection. Stress analysis and balancing. Specifications, standards, quality control.

Microscopic Examination

Condensed from "Metal Treatment"

Although the microscopical examination of metals and alloys plays a vital part in research, development and teaching, it is considered that many excellent research papers and text books have been and are being spoiled through the inclusion of photomicrographs of inferior quality. Especially is this true for some of the corrosion and heat-resisting nonferrous metals (and austenitic stainless steels) which are difficult to etch by the usual chemical methods.

A further disadvantage of the present-day photomicrograph is that it is in monochrome. The author has found that these monochrome photomicrographs can be improved by the use of a developer, such as Kodak D.158, which gives a blue tone to the print and has been used in the case of aluminum and magnesium alloys and the austenitic stainless steels. Similarly, a developer, such as Kodak D.156, which gives a brown tone to the print, has been used for photomicrographs of steels which show the presence of either pearlitic or martensitic types of structures.

This paper, then, resolves itself into two main parts. They are:—

(1) The improvement of methods for the successful etching of certain nonferrous alloys; and

(2) Methods of rendering the metallic structure as actually seen through the microscope in the forms of (a) colored transparencies for lantern slides; (b) color prints for the illustration of research papers and text books.

Several electrolytic reagents for wrought aluminum alloys that contain 7% magnesium are given in the literature, such as aqueous solutions of ammonium chloride, sulphate or citrate, were tried out with little success. Promising results were obtained, however, with aqueous solutions of a mixture of nitric and hydrofluoric acids. Further trials with this series of mixtures showed that the best results were obtained from the following composition:

Nitric acid (1.42 sp.g.)	2.0 mls.
Hydrofluoric acid (technical, 40%)	0.1 mls.
Water to	100.0 mls.

This reagent proved to be satisfactory over a range of 2 to 6 volts, using a current density of 0.3 amp. per sq. cm. and an electrode distance of 3 in. In practice the potential was maintained constant at 2 volts. Under these conditions a satisfactory microstructure could be obtained after an etching time of 2 min.

Transparencies of the microstructure of metals and alloys in their natural color are of the greatest use to the metallurgical student. Such colored slides are also very satisfactory for the illustrations of scientific lectures. In view of this the author has adapted the Vickers projection microscope so that suitable colored transparencies may be produced in conjunction with a Leica 3B camera. (K. J. B. Wolfe. *Metal Treatment* (Br.), Vol. 13, Spring 1946, pp. 25-40.)

From a study of the many photomicrographs (some in color) included in this paper it is evident that the author has developed excellent techniques for the electrolytic etching of many difficult structures. Details of his methods and equipment for electrolytic etching and for making photomicrographs and transparencies in natural color merit the attention of students and metallurgists.—The Editors.

Research for Small Industries

Condensed from "Steel"

Basically, research may be divided into two fields of endeavor: Fundamental Research and Applied Research. In general the smaller business will be concerned with the latter because it is primarily involved in activities where the time factor and the limitation of funds necessary delineate the scope of operation.

In industry, particularly in many small plants, some effort has been made to establish a semblance of technical control. Such control work must not be confused with research; the two activities cannot be carried on successively by the same personnel. Real research requires high degree of concentrated effort, which cannot be obtained if the program is constantly interrupted. Once established, a research program must be free from interference by management.

Successful direction of research programs calls for broad experience and administrative ability and, most important of all, a generous amount of good common sense. Results come through people, and proper direction of personnel is, in the final analysis, the difference between success and failure of any research program.

It has been estimated that there are more than 17,000 manufacturing firms in the United States doing $500,000 or more business in annual gross sales, of which less than 2½% are reported to have research and development facilities. Those reporting the National Resources Planning Board spend annually an average of 2% of their gross sales for research. (Waldemar Dietz. *Steel*, Vol. 118, May 27, 1946, pp. 112-115.)

Die Castings in the '46 Car

Condensed from "Die Casting"

A survey of 1946 model cars shows die castings being used for grilles, headlamps, parking lights, molding and radiator emblems, instrument panels, control elements and accessories, and steering wheels with horn rings. In all, the die casting is highly polished and plated. Except for Cadillac, most other radiator grilles are built up from units comprising several bars in each section. Many include several sections, and Chrysler achieves a striking appearance by extending the major horizontal bars of the grille in separately die cast bars that extend back along fenders.

In the lowest price range, where the volume warrants stamping dies that cost much more than those for die casting, grilles formed from sheet steel are used. Piece cost per grille is less and weight is lower but, even with good plating, the chance of red rust after prolonged use exists. Die castings are not subject to red rust and are preferred on this among other scores when their somewhat higher cost is justified.

Even cars limited to stamped grilles often have moldings or other die cast trim

added for appearance. Die castings that serve purely mechanical purposes and do not affect appearance continue much as for many prewar years, although the number of die castings of this type in some cars has been increased.

Besides carburetors, window regulators, lock parts, fuel pumps, windshield wipers, oil seal holders and a host of other more or less conventional parts, there are now many transmission elements, especially for the automatic or semi-automatic types, some parts for brake systems, several for raising and lowering convertible tops, some in steering systems and electrical systems, and others in accessories. Ford has added a small die cast expansion chamber to reduce pulsations in the vacuum line to wipers and to make them operate more quietly.

It is significant that die castings with inserts of other metals are easily made, and there is no telling what may develop along this line if car and engine designers should ever decide to explore fully the possibilities of large die castings for major engine and other large components. (*Die Casting*, Vol. 4, July 1946, pp. 18-20.)

Gamma Ray Inspection

Condensed from "Western Machinery and Steel World"

Military equipment for World War II had to be built of new materials with superior physical properties. This necessitated rigid and thorough inspection methods. Many inspection methods have been developed to investigate the internal conditions of materials opaque to light.

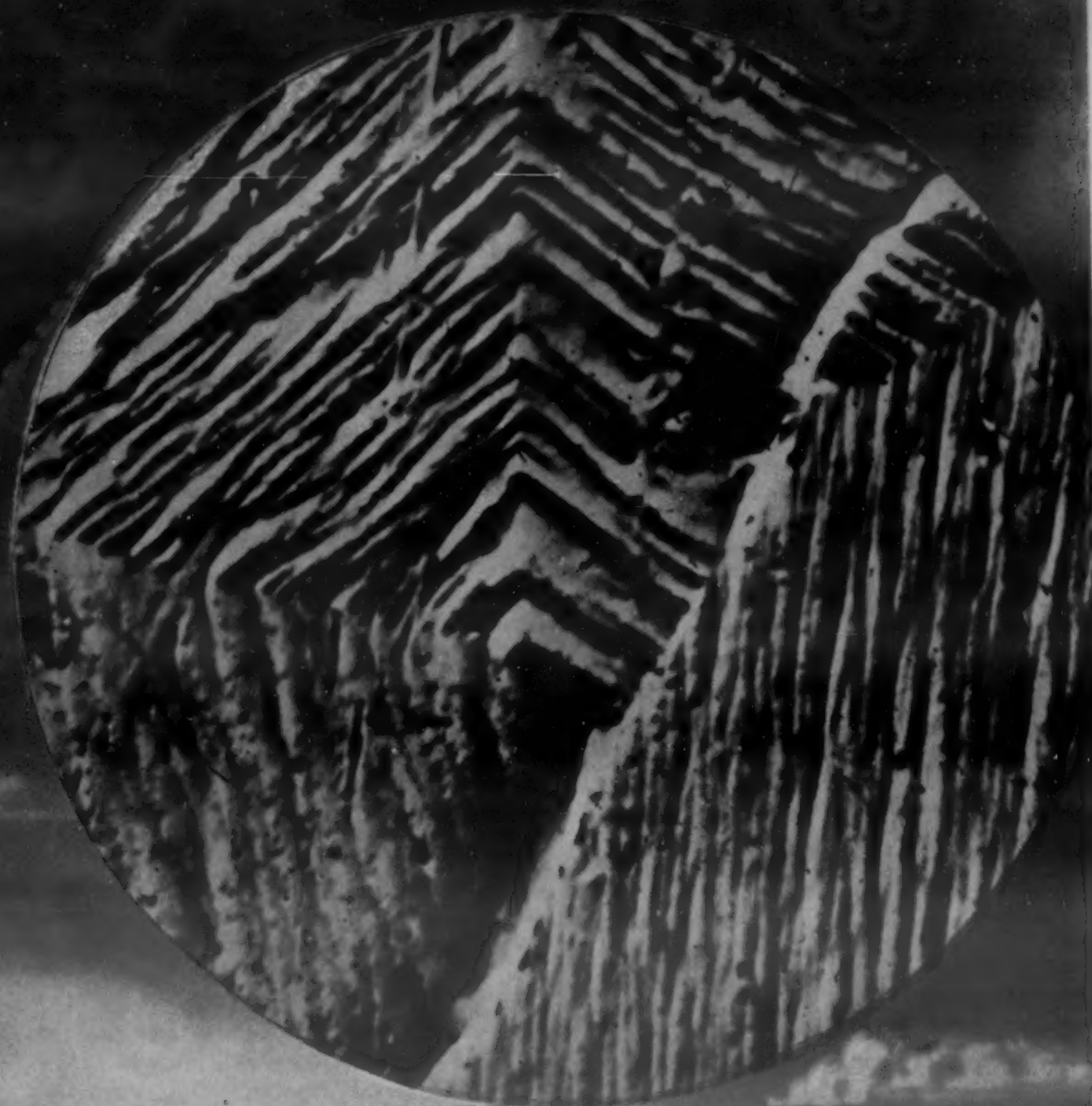
Radium or gamma rays, due to their extremely short wave length, successfully penetrate all opaque matter and thus offer a way to judge the subsurface quality of materials. Fundamentally, the gamma ray examination method is similar to X-ray examination, with gamma rays used instead of X-rays. Gamma rays have the advantage over X-rays in that they require no bulky equipment and can, therefore, be used in places inaccessible to X-ray equipment.

Gamma rays are produced by the disintegrating atoms of radioactive elements. The resultant radiation is composed of corpuscular alpha and beta rays and the electromagnetic gamma rays. Due to their extreme short wave length, gamma rays can penetrate materials that are opaque to comparatively long light waves.

The penetration power of gamma rays decreases as the density of the material under examination increases or the material thickness increases. Thus, more gamma rays would penetrate an area containing a gas cavity than the surrounding solid material.

To make full use of the fact that these rays are constant and continuous, in all directions, many parts can be placed around the radium pill and inspected simultaneously. The thinner objects are, of course, placed farther from the radium.

Due to the injurious biological effect of radioactivity, great care must be taken when handling radium for industrial inspection. (W. W. Offner. *Western Machinery & Steel World*, Vol. 37, July 1946, pp. 118-121.)



BOOK REVIEWS

Steel Castings

THE METALLURGY OF STEEL CASTINGS. *By Charles W. Briggs. Published by McGraw-Hill Book Co., Inc., New York, 1946. Fabrikoid, 6¼ x 9 in., 633 pages. Price $6.50.*

A few years ago, Mr. Briggs wrote for the Steel Founders' Society of America their "Steel Castings Handbook," which has undoubtedly been of the greatest value alike to designers, buyers and producers of steel castings. It is most gratifying, therefore, to note the publication of the present authoritative text, in which the technical aspects of steel casting production are gone into in far more detail than was possible or desirable in "Steel Castings Handbook."

To the present reviewer, too, the title "The Metallurgy of Steel Castings" is particularly welcome. A generation ago, the metallurgist was still regarded as such an interloper in the steel foundry industry that it seemed desirable to introduce what was really a steel foundry metallurgy, under the broader title "The Steel Foundry," for fear foundrymen generally would not trouble to read the volume. It is good to realize that today the metallurgist is no longer mentioned in the slightly sarcastic tone once so frequently heard.

As stated in the preface, the volume under discussion is based to a considerable extent upon lectures delivered before groups of technical and operating men of the steel foundry industry. The sources of the subject matter, therefore, are in part Mr. Briggs' own valuable investigations at the Naval Research Laboratory, and in part his wide reading of the technical literature of the subject.

It is perhaps not captious to say that the chapters based upon the authors' own work are rather obviously better balanced contributions than those that owe their authority more largely to the work of other writers. This is the more true because in so many cases the work of others is introduced by some such phrase as "A number of experiments have been made," or "Another classification has been made by so and so," and the reader is left in doubt as to the exact conclusions Mr. Briggs wishes to draw from these discussions. The very full lists of the works quoted, however, which are given at the end of each chapter, are most valuable to the student of the subject.

One hundred and twenty-five pages are devoted to acid and basic steel making practice, and a further 30 pages to a valuable summary of existing knowledge of deoxidation, gases in liquid steel, and their effects upon porosity and inclusions in the finished castings. The discussion of steel making practice touches so lightly upon the dollar and cents aspects of the subject that the "operating men, workers and apprentices" referred to in the preface would derive but little guidance from it, in trying to grasp the underlying reasons for the choice of one process or another for producing steel for castings in a particular locality.

In general, however, these first three chapters should be of real value to metallurgists and melters who wish to know the best ways to make steel for castings, and who until now have had to read endlessly about making steel for ingots, in order to find the little that has been written on the subject they are so vitally interested in. One could wish, also, that Mr. Briggs could have felt free to discuss more frankly the shortcomings of the "partial-oxidation" process for the manufacture of acid electric furnace steel, instead of contenting himself with damning it with, to say the least, particularly faint praise.

An unduly short chapter on "Tapping and Pouring," is followed by 173 pages on liquid contraction, solidification of steel castings, gates and risers, contraction in the solid state, and hot tear formation. Here the author is dealing with phases of his subject in which his experience is first-hand, and these are probably the most valuable chapters of the book. The user, the designer and the producer of steel castings will be richly repaid by a careful study of these pages, in which they will find set forth the basic principles that should govern the designing of castings, the manner of producing the molds in which they are made, and the way in which the molds should be filled with liquid steel.

In a little over 100 pages, the characteristics of molding sands, the materials used to bond them, and the effect of molten steel upon molds made of these materials are clearly and forcefully described. As in the chapters on steel making, somewhat less emphasis is placed upon the reasons for the choice between different molding mediums, such as "green" or dry sand, cement bonded sand, etc., than upon the purely technical aspects of the subject. Thus, the appeal here is more to the foundry engineer and metallurgist than to the practical-minded man, but the latter too could profit greatly by a careful reading of these pages.

One is moved to wonder, in a volume otherwise so free from faults of printing, why what the author properly calls "washes," are dubbed "washers" in the page headings of one of these chapters. The only other similar fault in the setting-up of the text is the failure, in the titles of some of the diagrams, to indicate the significance of letters or figures used in the cuts themselves.

The discussion of casting defects in the five pages of Chapter XII might seem disappointingly brief, were it not that in the previous 280 pages there is so much reference to the bad results of not following the practices discussed that but little is left to say under the definite head of "defects."

Methods of cleaning the castings, after they have been removed from the molds, are covered at considerable length. The important subject of heat treatment and metallography is well explained, and the effect of various heat treatments upon the physical and mechanical properties of the steel are shown in considerable detail.

A particularly interesting chapter is devoted to the welding of steel castings, in which the basic principles of welding are adequately explained, and the satisfactory results of properly controlled welding processes are demonstrated. In particular, it is heartening to read the unqualified endorsement of the use of welding to produce a finished article from several castings, or from castings and rolled parts, instead of trying to make the piece in a single mold, often with most unsatisfactory results.

Non-destructive methods of inspection, especially radiographic and magnetic particle testing, are dealt with in a concluding chapter. Three hundred and thirty-four well chosen illustrations and diagrams and some 86 explanatory tables greatly assist the reader in grasping the invaluable information included in the volume.

—JOHN HOWE HALL

Diemaking Techniques

SIMPLIFIED PUNCH AND DIEMAKING. *By James Walker & Carl C. Taylor. Published by The MacMillan Co., New York, 1946. Cloth, 5¾ x 8¾ in., 235 pages. Price $5.00.*

Apparently designed as a textbook to be used by anyone contemplating diemaking as an occupation, this volume leads the reader through the various steps of die production. Starting with a simple plain round blanking die, the succeeding chapters consider each of several more complicated forming and blanking dies, on through to some types of drawing dies.

To further round out the apprentice diemaker's knowledge, the book discusses machines and tools used in diemaking, devotes a chapter to a manufacturing problem and its solution, and stresses safety rules in both diemaking and press operation.

—T. C. DUMOND

Other New Books

KODAK DATA BOOK ON FORMULAS AND PROCESSING—THIRD EDITION. *Published by Eastman Kodak Co., Rochester, N. Y., 1946. Paper, 5¾ x 8½ in., 72 pages. Price 25 cents.* This new or third edition incorporates a number of changes to bring it up-to-date; one of these is a new section on Negative Faults, how to recognize them and identify their cause. It contains a comprehensive list of Kodak formulas, and is designed and punched to replace earlier Formulas and Processing sections in the Kodak Reference Handbook. It is the first of the Kodak Data Books to incorporate the company's new method of designating data book revisions.

New Materials and Equipment

New Plastic Shrinks on Parts to Form Protective Covering

A plastic material that shrinks when dried from a wet condition without losing any of its physical properties has been developed by the Plastics Div., *General Electric Co.,* Pittsfield, Mass.

This material affords a means of protecting many industrial products. It may be incorporated in the design of the product itself such as covering for bus-bar insulation, as terminal ends, and as electrical or mechanical seal for wires and tubing. It can also be used as a temporary protective during storage and shipment, or during the manufacturing processes of the finished product. For example, it can be used as coverings for cable ends, grips, for pliers and wrenches for insulating purposes, or for protecting threaded parts.

To use the material, it is immersed in a special dilator solution for 2 to 4 hr. This expands the plastic as much as half again its normal size. In this expanded condition the unit is placed in position and allowed to dry. It shrinks to smaller than its original size and forms a tight fit.

The material, dried, has a tensile strength of 2000 to 4000 psi. It is formulated for good heat stability so that it can withstand conventional high temperature baking cycles. For example, at 320 F it will remain stable for 2 to 3 hr.; at 212 F for 2 weeks; at 176 F, indefinitely.

The material is not affected by commonly encountered alkalis, acids and solvents. Chemicals such as hot oxidizing acids, cyclic ketones and chlorinated aromatic hydrocarbons have some effect.

Caps and sleeves from this material are not damaged by moisture, either by direct contact or by an atmosphere of high relative humidity. Tests have shown that when the interior of tubing or an assembled unit contains silica gel or other hygroscoping agents, there is negligible passage of water vapor through the cap or sleeve.

The caps and sleeves are made in any desired length and in diameters up to an in.

While in its swollen state, the cap is placed over the part to be protected. It will shrink tight around the part.

Giant Spot Welder Designed for Structural Steel

A large portable spot welder has been developed by *Sciaky Bros., Inc.,* 4915 W. 67th St., Chicago. The welder can weld up to three thicknesses of ½-in. structural steel without removing rust and scale.

Its chief application is on the prefabrication of large structural units in shops. Other uses include mass production of large assemblies in railroad, marine, truck and bus shops, where parts can be joined by overlapping or flanges.

Welding through the rust and scale is accomplished by an electrically-controlled sequence which consists of (1) a pre-weld period of high pressure and low current which burns off oxide, (2) a high-current welding period during which electrode pressure is reduced for greater efficiency, and (3) a post-weld period which retains the high current under high pressure to prevent coarse structure and internal cracks.

Current is interrupted and high pressure retained for a final forging action. The speed of welding is from 2 to 25 spots per min., depending upon the thickness and degree of scale.

Where high carbon steels (above 0.20%) are to be welded, a quench and post-heat period is provided to eliminate the hardening caused by welding high carbon material.

Process Prevents Carbide Segregation in High-Speed Steels

The *Jessop Steel Co.,* Washington, Pa., announces in collaboration with the *Barium Steel & Forge Co., Inc.,* Canton, Ohio, a new method of processing high-speed rounds in diameters greater than 4 in. The new process is known as Vee-Oginizing.

The purpose of the process is to provide a uniform carbide distribution throughout the piece and thus avoid the brittle carbide pattern often found in large rounds of high-speed steels. The carbide segregation is usually located at the center of the steel round's cross-section; this process is said to eliminate this central segregation and give a more uniform carbide distribution in the piece.

Electropolisher Prepares Both Ferrous and Nonferrous Specimens

A new electropolisher for polishing metallurgical specimens, developed by *Buehler Ltd.*, 185 W. Wacker Drive, Chicago 1, can be used with both ferrous and nonferrous metals.

In this polisher the specimen is made the anode of an electrolytic cell. Charged atoms or ions from the specimen enter the electrolyte, resulting in a polishing film which covers the surface of the specimen and offers resistance to the passing of the current. Since this film is thinner on the high spots, more current flows in these areas and, consequently, more material is removed.

One of the advantages of electropolishing over mechanical polishing is the freedom from disturbed metal on the surface of the sample. This is especially important with those metals, such as the austenitic stainless steels, which are particularly susceptible to cold working. In addition, electropolishing is faster, requiring generally less than a minute after the sample has been prepared with fine emery paper.

Many samples, too, may be etched immediately after polishing, with the same solution, by reducing the applied voltage. However, electrolytic polishing is not to be considered the best method for all samples. Mechanical polishing is to be preferred at present for inclusion and porosity examinations, and some other special work.

The mechanical operation of the Buehler-Waisman electropolisher is simple. The electrolyte is contained in a stainless steel tank, hinged at the back. The specimen is fitted over a hole in this tank, and is brought into contact with the electrolyte by tilting the tank down. This action also operates a mercury switch, which starts an agitating pump.

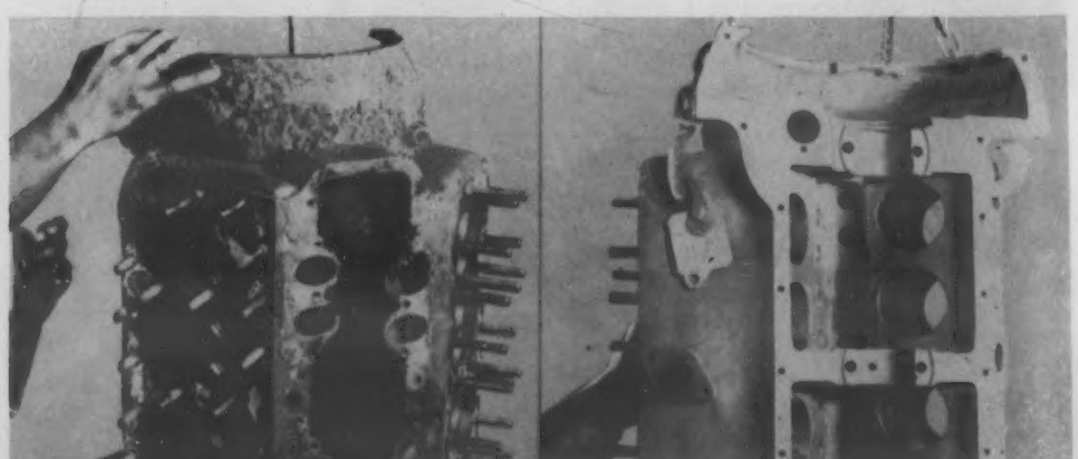
Hot Tank Cleaner Is Combination of Two Cleaning Agents

A new noninflammable hot tank cleaner has been introduced by *Turco Products, Inc.*, 6135 S. Central Ave., Los Angeles. It removes carbon, paint, grime, grease, gums, heat hardened resins and heavy dirt from steel and other ferrous metals.

Named Ferrex, it consists of a combination of two cleaning agents, an alkaline solid and a direct action liquid solvent. Specifically designed for use on steel, cast iron, bronze, copper and red brass, the cleaner utilizes a water solution and a hot tank, preferably with air agitation, to penetrate and "wet out" carbon smut and lead deposits, emulsify petroleum residues and saponify animal and vegetable oils.

The solution can be used over and over again with little depletion of strength. Since it contains no inert ingredients, wastage is eliminated.

This cleaner is applicable in automotive motor reconditioning, and in cleaning petroleum, railroad, diesel and farm equipment and tools.



Before (left) and after (right) cleaning an automotive engine with Ferrex.

Steam Cleaning Machine Features Automatic Control

A vapor steam cleaning machine for ...aning road, construction, railroad, marine ...d production machinery, auto and truck ...dies and engines, airplane fuselages, ...lls, windows, tanks and vats, and for ...ipping paint, is announced by *White ...gineering & Mfg. Co.*, 128 W. Passaic ..., Rochelle Park, N. J. Known as Model ...0-46B, the machine is manufactured ...her as a stationary unit with base, a ...vable unit with casters, or as a trailer ...rried unit.

The equipment has two easily accessible ...lves that enable one man to operate the ...chine. The pressure, when once set, is ...tomatically controlled throughout the ...aning operation. Adjustment of the mix...re is made possible by one of these two ...lves, which permits regulation from full ...ncentration of cleaning compound to clear ...por for rinsing. The unit has a system of ...stantaneous electric ignition that per...its the working pressure to be rapidly ...ached. The operating pressures are 75 to ...25 psi.; normal pressure is 100 lb.

The cleaner burns No. 1 fuel oil, kero...ne or light oil. It can be used with any ...gh grade steam cleaning material of stand...d make. The cleaning compound is in...cted into the steam beyond the pump. ...his prevents residue from fouling the ...mp. The capacities of the machine are: ...00 gal. per hr.; fuel tank, 11 gal.; com...und tank, 15 lb.

● Dr. Johan Bjorksten, Industrial Re...arch Chemist, announces the development ...f a new brass corrosion inhibitor, now ...anufactured by the *Bee Chemical Co.*, 63 ... Lake St., Chicago, under the trade name ..."Brass Lyfe." It is furnished as a 10% ...lution of the active organic chemical, in ...utyl cellosolve. It is specifically for copper, ...nd is not effective on any other metal than ...pper alloys. It is miscible with oils, ...bricants, and lacquers, and added to these ...t completely stops the corrosion of copper ...ontaining alloys, whether this is due to ...xygen, organic acids, or amines.

Spacing Device Automatically Positions Work for Drilling

The *Bullard Co.*, Bridgeport 2, Conn., has ...eveloped a hydraulically actuated mecha...nism for positioning the work in operations ...nvolving the drilling, tapping, reaming and ...oring of holes.

The machine, known as the Man-Au-Trol ...pacer, consists essentially of a flat platen ...mounted on a carriage and base. When ...pplied to a drilling machine, this platen ...an move both longitudinally and trans...versally. The positioning of the table is ...one hydraulically.

The final position of the table for any given setting is reached by a selected pair of pistons—one controlling each direction of motion—coming in contact with their stops. They are locked in this position by the action of a master control piston acting along each axis. The table can be traversed from one pre-determined position to another by means of two selector controls: one for

This spacing device for jig drilling accurately positions the work by means of an hydraulic actuated mechanism.

lateral positions, the other for locating longitudinal positions.

These units are made in two sizes: the larger one is suitable for use under radial drills, and the smaller one under sensitive drills. The spacer is designed for jig drilling by machine setting, thus eliminating the use of drill jigs.

In using the machine, the jig drilling requirements are charted on the blueprint; the operations, as required, are then set in the machine in accordance with the chart.

Porcelain-Like Finish Protects Furnace Interior

The development of a semi-glazed, porcelain-like finish is announced by The *O. Hommel Co.*, Pittsburgh. The finish is called Porcelanite. It can be used for protecting cold rolled and cast iron burning racks, burning tools, iron and glass furnace interiors, saggers, lehrs, decorating kilns and ladle-linings.

This semi-glaze finish prevents burning racks and tools of cast iron and steel from scaling. Stainless steel tools can be readily cleaned after being coated with Porcelanite, and helps extend the life of the paint.

When applied over brick and clay in furnaces, it provides protection against the corrosive action of gases, flue dust and slag. It prevents discoloration of molten-glass, china-ware and porcelain enamels by the iron oxide present.

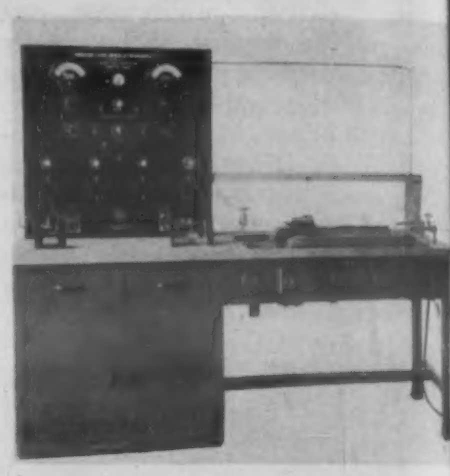
Porcelanite can be sprayed or applied with a brush. It air-sets, and the oven can be fired immediately.

Miniature Plating Laboratory Permits Controlled Plating Test

The *Hanson-Van Winkle-Munning* Matawan, N. J., has developed an ele plating control table—a miniature pl laboratory—designed for either ro control of plating solutions or for rese work on electroplating problems processes.

With this control instrument test p can be plated under closely controlled ditions so that the results of additions purity removal treatments and variation operating conditions can be observed. a few hundred milliliters of electrolyte required to conduct these tests.

The Diggin electroplating control t consists of laboratory table, constructe steel, with a corrosion-resisting finish. working surface is calcite-free alberene s The table has a large storage cabinet which a small motor generator and ba



An electroplating control table such as t can be used on many electroplating pr lems as well as for routine control

can be installed, and two drawers for ho ing anodes, cells, leads, etc. Above working space on the right side of the ta is a 36-in. x 36-in. control panel on wh are mounted the instruments and serv outlets required for electroplating tests.

Specimens are prepared for plating, rins or given special treatments after plating glass cells. These cells, six in number, fitted by rubber gaskets into a stainl steel tray. Three of the 1500 ml. cells r on thermostatically-controlled hot pla These positions are used for hot elect cleaners, hot pickles and the final hot wa rinse. The remaining three cells are u heated and are used for rinsing, picklin cyanide dipping or bright dipping.

● New rhodium plating developments *P. R. Mallory & Co., Inc.,* Indianapol Ind., make possible heavier deposits, wi the desirable hardness, brilliance and co rosion resistance inherent in metallic rhod um. At the same time, the process is s to assure freedom from shadows, pin hol and blisters which normally accompa heavier coatings.

Instrument Controls Variables in Continuous Processes

An instrument designed for control temperature, pressure, flow and other v ables in continuous processes is annou by The *Foxboro Co.*, Foxboro, Mass.

The controller, known as Model 40, be easily changed from one type of con to another. Setting of the proportio band, from 0 to 200% or higher, is m by turning a thumb wheel. Reversal instrument action is made in a like mann The range of reset is 500:1 and, althou not considered critical, is a continuous justment.

Elimination of the reset and derivat functions can be accomplished when desi An adjusting device permits zeroing pen without realigning the control po A transfer switch enables the operator change from manual to automatic contr or vice versa, with no valve motion.

The unit is made as an indicator as w as a single-pen and multi-pen recorder, a is available for on-off control action, pr portional, proportional and reset (Sta log), proportional with derivative, and pr portional and reset with derivative (Hyp Reset).

● A new pattern plate has been announc by The *Kindt-Collins Co.*, 12651 Elmwo Ave., Cleveland. The plate has knurle steel inserts cast integrally into the pla The inserts are so placed around the outsi perimeter of the plate as to distribute an equalize wear at flask contact points. T surface of the plate is machined to preve sand slippage. The plate is ground to plus or minus 0.003 in.

One-Hundred-Ton Press Developed for Plastic Molding

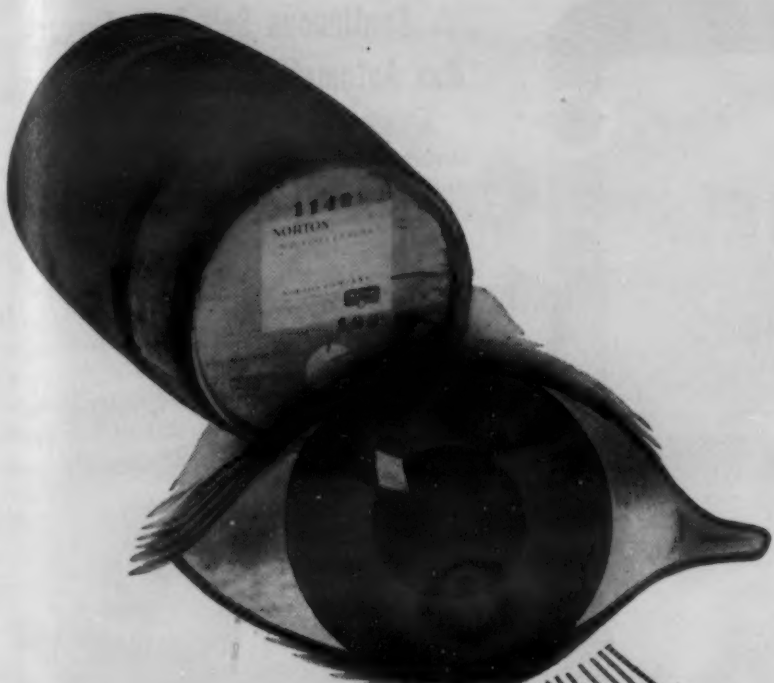
A press of 100-ton capacity suitable fo either compression or transfer molding o plastics is announced by The *Watson-Still man Co.*, Roselle, N. J. The press is semi automatic. The degassing is controlled b time rather than by limit switches; thi allows complete range of die opening an ready adjustability.

Open-four column construction is pro vided for maximum dissipation of hea that otherwise would be taken up by th press frame. This open-column construc tion also permits full accessibility to mold and provides an adjustable opening.

The power unit includes pump, valv and controls. The pump is a radial piston type with built-in short stroke control. Th power unit can be steplessly adjusted to within 25% of the total tonnage of the press.

Some of the operating characteristics of the press are:

Die Space —	20 in. x 21 in.
Stroke —	12 in.
Operating Pressure —	2200 psi.
Speeds (in. per min.)—advance	260.0
pressing	13.5
return	220.0



THE REFRACTORY *looks* AT THE JOB

THE melting of all non-ferrous metals — in pit furnaces, direct arc type rocking furnaces, induction and high frequency furnaces — is the type of job where Norton Company's high temperature cements and prefired shapes find logical application.

Mixtures made from fused alumina, silicon carbide or fused magnesia are recommended for melting aluminum, copper alloys and nickel-chromium, nickel-silver, cupro-nickel and cadmium-bronze alloys.

NORTON COMPANY
WORCESTER 6, MASSACHUSETTS

NORTON REFRACTORIES

Continuous Salt Bath Furnace Has Automatic Quenching Mechanism

A continuous salt bath furnace with an automatic quenching mechanism, originally designed for cyanide hardening the ends of control levers, has been completed by *The Bellevue Industrial Furnace Co.*, 2971 Bellevue, Detroit 7. With changes, it can be used for hardening other parts, including jobs where the parts can be processed in baskets.

A ferris-wheel type automatic loader is located at the charging end of the furnace. It is equipped with metal pockets to hold

Close-up of ferris-wheel type loading mechanism showing fixtures for holding parts to be treated.

the fixtures carrying the control levers. These loading pockets are spaced and synchronized so as to allow the fixture holding the parts to be placed in the slots provided on the continuous chain. The chain travels the entire length of the machine, which includes furnace and quench tank.

As the fixture is placed on the chain, the work is carried through the salt and the entire length of the furnace. Reaching the discharge end of the furnace, a rotary arm operating automatically and synchronized with the speed of the chain picks up the fixture containing the work and drops it into the quench tank.

The quenching operation is completed in four sec.; this speed may be changed to meet metallurgical requirements.

New Protective Coatings Can Substitute for White Base and Finish Coatings

Watson-Standard Co., Pittsburgh 12, Pa., announces a new series of protective coatings, known as R_x Aluminum System, as an alternate for white base and finish coatings during their present scarcity.

The series includes coatings for black plate, of interest to lithographers, container manufacturers and metal fabricators. The coatings are said to provide a good printing surface on the base coat.

There is also a coating for reflectors, stoves and heaters that is heat resistant at elevated temperatures. These are also useful for such products as toys, drums and pails.

Threading Tools and Reamers Have Carbide Cutting Edges

Announcement of a new line of standard carbide tipped threading tools, Style M-15, is made by *Metro Tool & Gage Co.*, 4240 W. Peterson Ave., Chicago 30. These tools are of the 60-deg. V-nose type. Primary clearance at the nose is 3 deg., with a secondary clearance of 6 deg. According to the manufacturer, these tips are made of a tough, wear-resistant grade of carbide particularly suitable for long run threading of steel parts.

A new line of solid shank and shell type expanding reamers has also been announced by the same company. These reamers have full length carbide cutting edges; they are also available in blades with high-speed steel.

The reamers are designed with a low expansion angle to lessen the O.D. grinding when resharpening, and have a 1/16-in. blade overhang to increase rigidity without loss of chip clearance. They are available in cutting diameters of from 1 in. to 6 in. Shell arbors are furnished with straight or Morse taper shanks.

● A new oil, grease, and water absorbent produced from an alumina silicate material and capable of absorbing from 120 to 140% of its own weight, has been announced by the *Blue Mountain Clay Co., Inc.*, Memphis, Tenn. Used on oily, greasy or wet floors, the absorbent eliminates danger of accidents due to slipping, at the same time keeping floors clean and minimizing chances of flash fires.

Low Melting Alloy Has Many Uses as a Molding Material

A new low melting alloy, for use as a molding material, has been introduced by *Trethaway Associates*, 37 Wall St., New York. The material is known as Moldaloy.

Listed below are some of the properties of Moldaloy:

Melting Point — 430 F
Hardness — 22 BHN
Compression Strength — 8000 psi.
Tensile Strength — 11,500 psi.
Shrinkage — 0.001 in. per in.

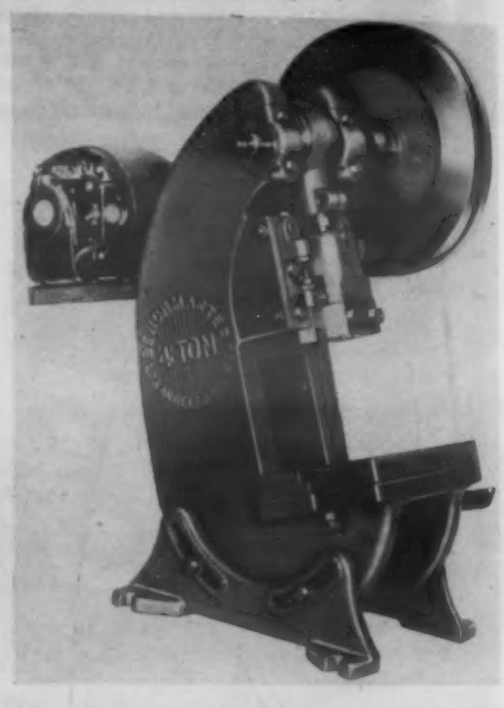
The manufacturer recommends the material for molds for casting low-temperature-fusing plastics, rubber molds, wax molds for precision casting process, models for engraving machines, master patterns, forming dies for thin sheet metals and thermal plastics, proof casting of molds and forging dies, chuck jaws for holding irregular shaped pieces, and protective coating on wood patterns and core boxes.

Four-Ton Punch Press Adaptable to High-Speed Production Operations

A new, four-ton bench punch press is now being produced by the *Benchmaster Manufacturing Co.*, 2952 W. Pico Blvd., Los Angeles 16.

The press weighs 215 lb., and operates at a speed of 285 rpm. with a 1725 rpm. electric motor. It has a precision-ground shaft that is keyed by means of a press fit to a large eccentric, thereby offering a shock-absorbing bearing surface. An oversize bronze bushing encloses the eccentric; full diameter bronze bushings encase the shaft at wear points.

The frames are cast in one piece from semi-steel, heat-treated and reinforced at stress points; they are mounted on two supports forming a broad stand cradle which allows the machine to be inclined for greater versatility in operation. The press has an open back that makes it possible for work to be inserted from the front as well as from the sides.



This bench punch press can be adapted to such operations as stamping, crimping and riveting.

When ram is in up-position, a 5¾-in. die space is available. The 6-in. x 8-in. bolster plate has a thickness of 1 in. and a 2-in. hole in its center. The fly wheel weighs approximately 50 lb. The manufacturer points out that although it was specifically designed as a punch press, this machine is adapted to do stamping, marking, punching, crimping, riveting and other high-speed production operations.

● *Kennametal Inc.*, of Latrobe, Pa., has developed a tungsten carbide composition, Grade K5H, for small tools used in precision boring of steel parts. It has a Rockwell A hardness of 93.2 Solid tools 3/32-in. to 5/16-in. dia., and 5/32-in. to 5/16-in. sq., are available, as well as blanks 3/32-in. to 3/8-in. dia. and 3/16-in. to 3/8-in. sq.

New Tool Permits Threading and Tapping at High Speeds with Safety

A new hand tool, announced by The *Thread Miller Corp.*, West Orange, N. J., is claimed to permit threading and tapping at high speeds in a lathe with safety to tools and operator.

The tool, known as the Grip-Slide Threading and Tapping Tool, is said to eliminate the hazard of projecting tap or die holder handles, and to speed threading operations by permitting higher lathe speeds. The tool can be used for cutting either right or left hand threads.

Another advantage claimed for this tool is that it eliminates the necessity for moving the tailstock back and forth when threading or tapping work in the lathe, thus preventing drag on the thread being cut. Sliding movement of the die or tap holder takes place on a hardened and ground guide bar concentrically true with the tapered shank that fits into the tailstock spindle.

The die or tap holder also is a hardened and ground piece having the bore for the guide bar concentric with the recess in which the die or tap is held. Thus, the tap or die is in alignment with the work held in the chuck of the lathe. The die or tap holder is a precision sliding fit on the guide bar, and the guide bar is ring marked at quarter-inch intervals for accurate duplication of thread length on parts.

In operation, the tool is secured in the tailstock spindle and the tailstock moved to a position which brings the tap or die near the work. With the tap or die inserted, the holder is grasped and slid toward the work. When the thread is cut to the desired length, the grip on the tool is released, permitting the holder to float on the guide bar, stopping cutting action; the lathe is reversed and the tool again gripped for backing off the die or backing out the tap.

The tool is furnished in two sizes. The smaller is for use in bench and small engine lathes, and the larger for use in larger lathes.

Lubricator for Band Saws Uses Spray

The *DoAll Co.*, 1301 Washington Ave., South Minneapolis, has introduced a unique spray lubricator for attachment on their high-speed band saws. It is said to furnish an economical, clean method of heat dissipation.

The attachment is simple to install, is designed for heavy duty service, and it operates from the standard air pressure line available in the average shop.

The spray head straddles the saw blade from the back side and directs twin streams of lubricated air against the teeth of the saw. Lubricant is thus forced under pressure in the form of metered mist into the saw teeth as it enters the work. Use of coolant is regulated by a metering valve. The work table does not get wet or messy.

The spray lubricator has been designed primarily for use in cutting nonferrous metals, but works equally well on many types of plastics and laminated material where friction between blade and work softens the material to a gummy state.

Control Unit Sensitive to Small Temperature Variations

The *Claud S. Gordon Co.*, 3000 S. Wallace St., Chicago, 16, has designed a new control unit for "straight line" temperature control. It has use in operations involving temperature in avoiding overshoot and undershoot temperature variations. It provides temperature-variation control for as low as 1/5 F.

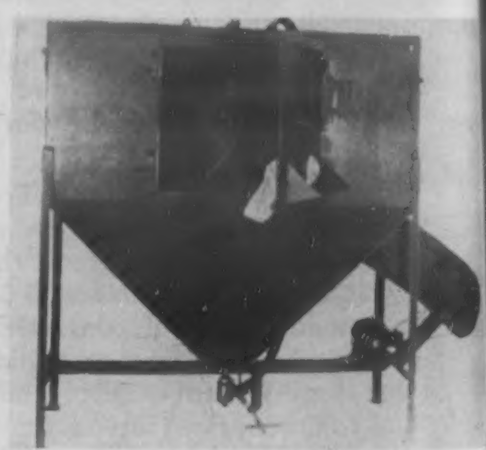
Known as Xactline, the unit can be used on all types of electric furnaces, ovens, and injection molding machines employing conventional millivoltmeter and potentiometer type controlling pyrometers. It can also be used on gas-fired equipment employing solenoid-controlled or motor operated valves.

It is housed in a cast aluminum case $8\frac{1}{4}$-in. high x $6\frac{1}{4}$-in. wide and 3-in. deep and is designed for surface mounting installation.

Sandblasting Machine Has Combination Loading Door

A sandblasting machine having armholes with cuffs in the loading door is announced by *Leiman Bros., Inc.*, 260 Christie St., Newark 5. It is a self-feeding sandblast with a sand magazine from which the sand is fed through the nozzle and on to the work. The sand is returned by gravity to the sand magazine to be refed to the nozzle.

A rotating basket device, motor driven, handles small articles like bolts and buttons. It tumbles them over and over as it rotates.



The sandblast shown here is equipped with a rotating tumbling basket device.

Meanwhile, the nozzle continuously sprays the lot with sand. For larger pieces of work, the basket can be removed from the cabinet, to make the entire interior space available. The operator then holds these larger pieces of work under the nozzle, turning each piece over and over until it is entirely cleaned.

The machine can be used for cleaning prior to finishing to remove rust, scale and carbon deposits and for cleaning castings of burnt sand deposits before the machining operations.

Heat Transfer Unit Achieves Temperatures of 2300

A new form of heat transfer unit, ca the Pebble Heater, capable of heating g above the operation temperatures per sible in metallic heat interchangers, been developed by The *Babcock & Wil Co.*, 1 Madison Ave., New York 10. T principle involved consists of raising high temperatures a constantly moving umn of pebbles made of a heat resis nonmetallic material, and then passing gas to be heated through the interstices the moving pebble column. The unit been successfully used to heat air to 23 F and steam to 1800 F.

One of the first applications of the Pe ble Heater has been for heating the used for combustion of fuels by us highly preheated air—temperatures can reached which far exceed the temperatu required for melting steel. In the field refractories, which covers the making materials for furnace constructions, a conti uous melting operation has been develop in which furnace construction materials, themselves very resistant to high tempe atures, can be melted and poured li molten steel, to give them even grea temperature resistance.

The heater consists of two cylindric chambers, one above the other, connec by a throat section of reduced diame By filling the chamber and throat with r fractory pebbles, permeable beds are form through which gases can be made to trav At the outlet of the bottom chamber, th is a mechanical feeder which controls t rate at which the pebbles are convey continuously back to the top of the upp chamber. The pebbles in the heater mo downward at a constant rate during th entire operation.

Fuel and air are burned in a combusti chamber, and the products of combustio flow through hot gas inlets into the u chamber and then upward through the be of downwardly moving pellets and out th stack at the top. The heated pebbles pa through the throat section to the low chamber.

At a point near the bottom of the lowe chamber, the gas to be heated is introduce The gases pass through a screen to provid uniform distribution, then travel upward through the heated pebble bed and leav at a point near the top of the lower chambe

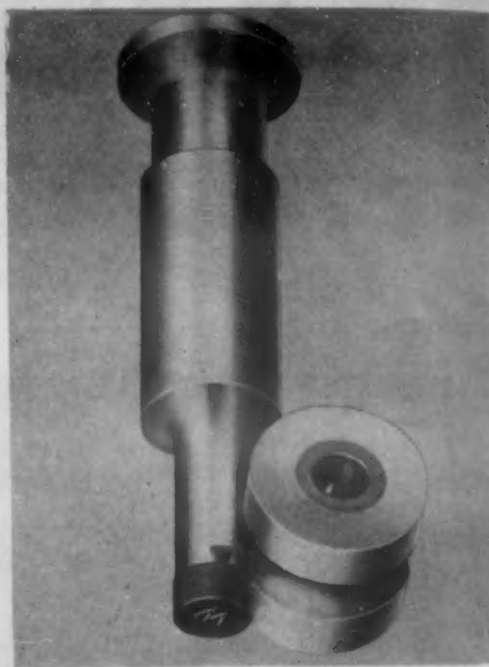
In operation, the pressures in the tw chambers are usually maintained at th same value, so that there is no gas flow through the throat section. Zero gas flow or a flow in either direction, can be main tained by automatic control of a damper i the exit stack of the upper chamber.

● A new universal fly cutter has bee introduced by the *Wendt-Sonis Co.*, Han nibal, Mo. The cutter does all kinds o ordinary and step milling operations on al types of materials. Only one cutter body i needed to handle 75% of milling jobs, sinc the inserted teeth are easily interchangeable Blades may be removed for sharpening o an ordinary bench grinder.

Punch and Compacting Die Combination Employs Tungsten Carbide Inserts

The *Penn Carbide & Alloy Casting Co.*, Canonsburg 2, Pa., are now offering a new punch and compacting die combination to the powder metallurgical industries. Dies are of the conventional tungsten carbide type. A heat-treated steel case is shrunk around a tungsten carbide insert. Punches, however, are produced with a dove-tailed insert which is locked into the shank for added protection during operation. This punch design is said to increase the bearing surface of the carbide and eliminate the possibility of mis-alignment caused by the braze taking a set when under pressure.

A new process makes possible the engraving of complex and intricate designs on punches, which are furnished with the proper draft for tablet compacting. Advantanges cited by the manufacturer are: high production runs, high polish, and savings in lubrication costs due to lower friction coefficient of tungsten carbide.



This punch and compacting die combination is used in producing powder metallurgy parts.

Noncorrosive Cutting Oils Permit High Cutting Speeds

A new series of transparent cutting oils, for use in high-temperature machining of metals, is available from *The Texas Co.*, 135 E. 42nd St., New York. Known as Cleartex A, A-1, B, DD and Britex B, these products contain a combination of sulphur and chlorine.

Addition of new ingredients makes possible high speeds in machining without the danger of corroding finished or semifinished metals, particularly nonferrous metals such as brass and copper. The color of the new oils equals pale neutral oils of the same viscosity.

Micrometer Measures Bores Around Center Obstructions

Measuring bores without removing boring bars is possible with the new inside micrometer manufactured by the *Tubular Micrometer Co.,* St. James, Minn. This new measuring device is used to determine bore sizes over or around center obstructions. It does not require removal of the boring bar and disturbing the cutter settings, but is placed around the bar in correct measuring position and the micrometer reading is taken.

These inside micrometers are made with hollow-box type steel frames. Because of this structural lightness, the micrometers are easy to handle. Bore measurements can be made without forcing the micrometer and, consequently, more accurate readings may be obtained.

The frames have a vacuum in the center to insure minimum expansion and contraction. Hand heat will not affect the micrometer reading for it is dissipated in the vacuum and does not distort or follow the metal frame. The frames are hydrogen brazed and are plated with copper, nickel and heavy chrome to resist wear and perspiration.

The spindle is made of hardened and ground tool steel. Micrometer threads are ground from the solid and lapped to a true fit with the barrel. Should the micrometer become worn through excessive service, there are three points where it may be adjusted for wear: the spindle bushing, the mandrel and the thread, as well as at the reading.

The standard range of sizes of this micrometer is from 8 in. to 28 in., and will cover bar diameters from 4 in. to 8 in. Each micrometer will fit over a variety of bar sizes. Thus, the 13½-in. to 18-in. set shown will cover any bar up to 7½ in. in dia. Mandrels in ½-in. steps will fit any bore diameters within the established range.

Gas Analyzer Quickly Detects Flue Gas Changes

A new instrument announced by *Davis Emergency Co., Inc.,* 146 Halleck St., Newark 4, N. J., is said to have extreme sensitivity to variations in the percentage of CO_2 in the flue gas. This sensitivity causes a quick response and enables the instrument to record a change 3½ sec. after the variation in CO_2 content of the flue gas has reached the analyzing cell. Because the analyzing cell is located close to the stack, the percentage of change is indicated almost as soon as it occurs in the stack.

Employing the principle of thermal conductivity analysis, new developments in cell construction permit the elimination of continuously operating suction pumps. The flow rate through the gas sampling line does not exceed 250 cc. per min; the minimum flow required is 20 cc. per min. This low rate of flow eliminates the need for extensive filtering trains and the necessity of employing dryers. The condensate and harmful acids are expelled automatically.

The pressure differential between the last pass of the boiler and the stack side of the barometric damper is all that is necessary to assure a constant free flow of gas through the analyzer cell at the desired rate.

Cold and Hot Air Dryer Applicable to Single-Stage or Successive Operations

A machine designed to dry loaded racks continuously before or after plating, or after any other type of water-solution dip, has been introduced by the *Optimus Equipment Co.*, 267 Church St., Matawan, N. J.

The machine is continuous in its operation, and works almost completely closed. It can be connected to an exhaust blower to draw off fumes. Any heating system—steam, gas, or electricity—can be employed. Drying time is usually from 4 to 6 min.

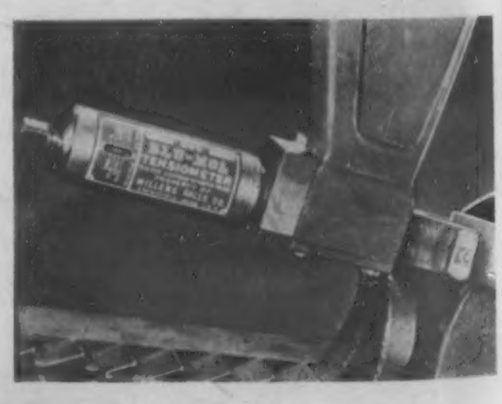
The dryer can be used as a single-stage dryer or in connection with a number of successive operations—alkaline, acid, or neutral.

The cold air system includes a blower and a series of nozzles. The hot air system includes an air-heater, recirculating blower, a damper to adjust the mixture of atmospheric air and re-circulating air, and the necessary nozzles.

Device Maintains Correct Blade Tension on Power Hacksaws

The *Millers Falls Co.*, Greenfield, Mass., has recently developed a "tensiometer" designed to set and maintain correct blade tension on power hack saws. It is a small cylinder, enclosing a strong, calibrated spiral spring; it is attached to the blade holder of the machine and acts as a shock absorber for the blade. It automatically compensates for changes of feed pressure, thermal expansion and contraction, and unusual shocks such as the blade striking a hard spot in the metal being cut.

By controlling any desired tension from 0 to 4000 lb. the device is said to improve the accuracy of cut, minimize blade breakage, and increase the cutting life of the



The tensiometer attached to the blade holder of a power hacksaw to control the blade tension.

blade. The machine operator, by reading the calibrated indicator, can set the tension at the desired figure. The tensiometer can be set by hand to a tension of 3000 lb. without using a wrench.

Grinding Wheel Suitable for a Variety of Materials

The *DoAll Co.*, Minneapolis 4, Minn., announces an all-purpose grinding wheel to grind any kind of material, including hardened alloy tool steel, annealed steel, stainless, Monel, bronze, aluminum, brass, hard plastics. The wheel is said to work equally well for heavy fast roughing cuts and fine finishing. It produces a finish comparable to that of a 300 grit wheel.

It can be used on all types of grinding machines—surface grinders, centerless, cylindrical, tool grinders, pedestal. No alteration to the machine is necessary, and the cutting rate is limited only by the ability of the grinding machine.

Because of the unique cutting crystals and method of bonding used, it is claimed that heavier cuts without sacrifice of surface finish or accuracy can be taken. The effective cutting edges of the crystals are broken down at a very slow rate, resulting in longer life to the wheel and requiring dressing at less frequent intervals. The structure is such that loading even when grinding soft materials is reduced to a minimum.

The bond used in making these wheels is insoluble and prevents them from weakening from use of coolants in wet grinding. On the other hand, the open structure is such that the work remains cool even when dry grinding.

The grinding wheels are available in Types No. 1 (straight), No. 5 (recessed one side), and No. 7 (recessed two sides). Sizes range from 1 in. to 14 in. in dia. by ¼ in. to 3 in. in thickness. Any size arbor hole is available.

Hard-Facing Electrodes Applied to Heavy Equipment Resist Abrasion

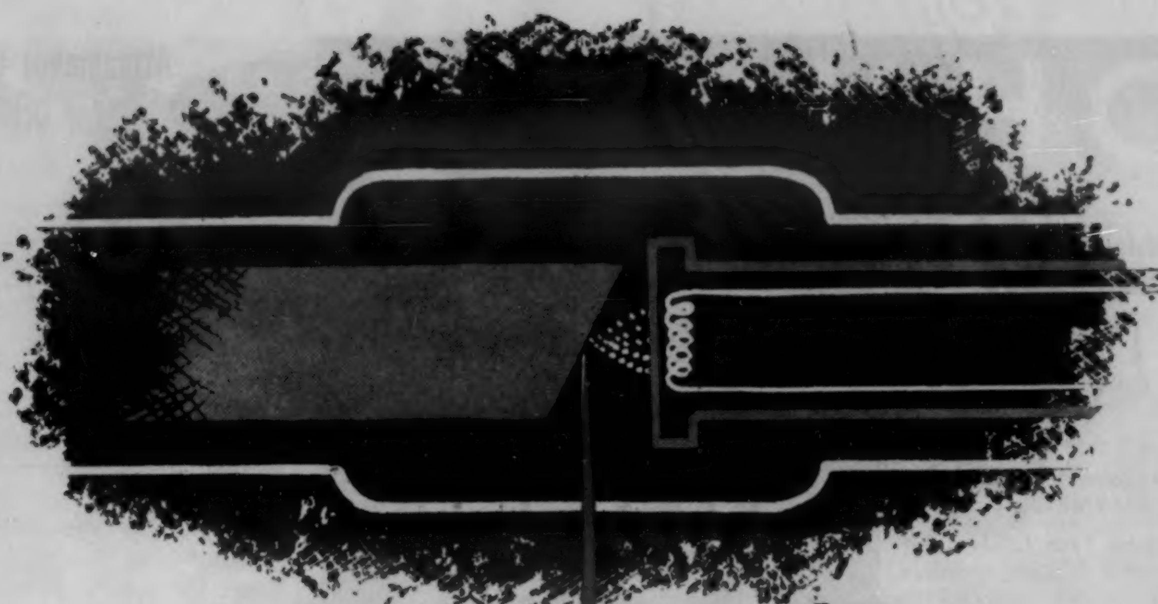
Stoody Co., Los Angeles, Calif., announces a new wear resistant electrode for hard-facing heavy equipment subject to earth abrasion and impact. The electrodes have an extruded flux coating, which is said to improve welding characteristics and simplify application.

The electrode is a fabricated rod consisting of mild steel tubes filled with alloying elements. The new coating is applied to the rod by means of an hydraulic extrusion press.

Some of the advantages claimed for the electrode are: good arc characteristics with either a.c. or d.c. machines; no slag interference; rapid deposition rate; can be welded in all positions; solid, dense deposits; and easy slag removal while deposit is still red hot.

Hardness ratings of the deposits average 56 on the Rockwell "C" Scale. The melting point is 2525 F, and the specific gravity is 7.80.

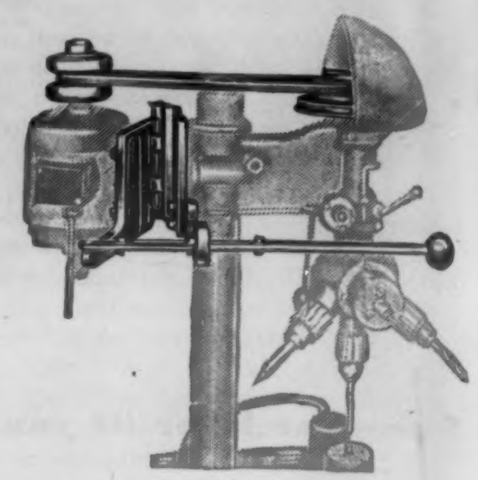
The weld deposit can be forged without loss of hardness, providing forging is done at red heat. Deposits bond well with manganese steel, and its use is especially recommended on wearing surfaces of all heavy equipment made from this metal.



Attachment Changes Speed for Drill Presses

Tool speeds must be changed frequently on drill press operations. Slow speeds for tapping—faster speeds for small drills—different speeds for larger drills. Very often drills and taps are ruined because they are not run at proper speeds. That means a big waste of money and time to replace broken tools.

The *Chicago Drillet Corp.*, 1729 N. Winchester Ave., Chicago 22, announces a method of obtaining correct drilling and tapping speeds on all drill presses without having to change belts or stop motor. Known as the Speed Changer, it can be set for any range of speeds desired.



Speed Changer shown mounted on a 4-position drilling and tapping turret head.

A standard drill press equipped with Speed Changer and a standard four-step cone V-belt pulley will have a speed range from 435 rpm. to 4550 rpm. The device is engineered so that all steps of the pulley can be used.

It can be installed on any make of drill press in a few minutes. No alterations to the press are required.

Angle-Dressing Attachment Increases Scope of Cutter Sharpener

A new angle dressing attachment, for use on its cutter sharpener, is now being manufactured by the *Edward Blake Co.*, 634 Commonwealth Ave., Newton Centre, Mass. The face of the dish wheel, used on this machine, is dressed by the standard-equipment diamond. The new attachment provides a second diamond for dressing the back and the periphery of the wheel to any desired combination of angles.

With the wheel formed to exactly the desired shape, deepening the gash and sharpening the face are performed in the same operation. This is especially advantageous when sharpening cutters having a large number of teeth.

The new attachment increases the scope of the Waltham Cutter Sharpener. This machine sharpens gear and thread milling cutters, circular form tools and multiple cutters from the smallest sizes up to 3½ in. in dia. It can be used for either radial or rake grinding, and operates either with index plates or with a pawl device which positions the cutter by locating either on the top or back of the tooth form.

A GOOD MORNING—IN PLASTICS

Arise and really shine with the new Telechron Musalarm. This wonderful bedside companion combines a radio, a clock, and a musical alarm in a handsome plastics case. And that's where No. 1 Plastics Avenue comes in with experience in designing and engineering so many plastics products.

The Telechron people insisted upon beauty . . . technical perfection . . . economical production. And they got all three in this compression-molded phenolic case from General Electric's *complete* plastics service.

Maybe you, too, are planning to bring out a wonderful new product. Whatever it may be, don't overlook the fact that plastics may be able to do for you what no other material can. Bring any plastics problem that may arise to G.E.—the world's largest manufacturer of finished plastics products. Plastics Divisions, Chemical Department, General Electric Company, 1 Plastics Avenue, Pittsfield, Mass. *Ask for a copy of the new illustrated booklet, "What Are Plastics?"*

EVERYTHING IN *Plastics*

G-E Complete Service — Everything in Plastics

Backed by 52 years of experience. We've been designing and manufacturing plastics products ever since 1894. G-E Research works continually to develop new materials, new processes, new applications.

No. 1 Plastics Avenue—complete plastics service—engineering, design and mold-making. Our own industrial designers and engineers, working together, create plastics parts that are both scientifically sound and good-looking. Our own toolrooms are manned by skilled craftsmen—average precision mold experience, 12 years.

All types of plastics. Facilities for compression, injection, transfer and cold molding . . . for both high and low pressure laminating . . . for fabricating. And General Electric Quality Control—a byword in industry—means as many as 160 inspections and analyses for a single plastic part.

GENERAL ELECTRIC

CD46-A16

General Electric plastics factories are located in Fort Wayne, Ind., Meriden, Conn., Scranton, Pa., Taunton, West Lynn and Pittsfield, Mass.

Automatic Control Unit Adapted to Five-Spindle Tapping Machine

An automatic control unit developed by the *Pond Engineering Co.,* Springfield, Mass., has been adapted to a five-spindle tapping machine to increase the production rate of certain stampings.

Five drill spindles are mounted on a standard three-spindle drill table, and two chain conveyors carry the pieces on equally-spaced carriers across the table and under the spindles. The pieces arrive under the spindles at equal time intervals, where station blocks, locating fixtures and a clamping cylinder are mounted.

Tapping heads fitted to each spindle are actuated simultaneously so that five holes are tapped at one cycle. This operation requires two different pieces to be handled simultaneously—one having three holes to be tapped, the other two. The conveyor drops the stampings into containers at the other end. Where pieces cannot be adapted to hopper or magazine feed, an attendant is required to place the pieces on the conveyors.

The control unit, Pond Operator Model 600, is motivated by three forces: 1⅓ hp. electric motor; a gear-driven, clutch-connected cam shaft; and four small air-valves, connected to a compressed air line which has a minimum of 70 lb. air pressure. Mechanical cams and more air valves may be added by extending the cam shaft outside the housing.

Cycle speed of the operator is adjustable from 2 sec. to 1 min., and longer cycles can be had on special order. The air valve cams are also adjustable for the frequency and duration of impulses per cycle.

External and Internal Gears Tested with New Model Gear Testers

The *George Scherr Co.,* 200 Lafayette St., New York 12, announces two new models of gear testers. Both have a maximum capacity of 15-in. center distance and thus constitute a new size in addition to the 9-in., 24-in. and 36-in. Parkson gear testers.

One of the new 15-in. models is equipped with a box-shaped upright which carries an adjustable bracket with means for clamping it in any desired position. This arrangement provides vertical centers for holding gears or pinions that are cut integral with their shafts or mounted on arbors.

The other new model has been specially designed for testing internal gears, either against the mating pinion or against a master. Whenever external gears are tested, the measuring pressure in the floating slide which contacts with the dial gage is towards the mating gear. However, when testing internal gears, the pressure has to be in the opposite direction.

Therefore, the internal model incorporates an arrangement, whereby the pressure can be reversed at will. In this way, both internal as well as external gears may be inspected equally efficiently for center distance, run-out, tooth thickness, and rolling action.

Both models embody a precision scale and over-size vernier for setting to correct center distance. The operation is by handwheel through rack and pinion.

Dilatometer Automatically Measures Thermal Expansion of Materials

An automatic dilatometer for continuous recording of the thermal expansion and contraction of a wide range of materials, including metals, glass, ceramics and plastics, is announced by the *Electronics Div., Sylvania Electric Products, Inc.,* 500 Fifth Ave., New York.

The equipment is designed to provide continuous graphic recording of the 12-hr. expansion and contraction cycles of samples. Measurements begun during the afternoon of one day may be automatically completed overnight. Except for set-up time, the instrument needs no attention during the 12-hr. recording cycle.

To eliminate the tedious plotting of instant values, the recording densitometer permits determination of true variations in length even when samples exhibit exceptions to the rule of elongation as a function of temperature. This makes the equipment particularly useful in connection with the laboratory study of ferrous alloys at thermal critical points.

The dilatometer includes a furnace or sub-zero cooling chamber, furnace thermocouple, concentric quartz tube, specimen thermocouple gearbox and support, transmission, contact mechanism, electronic relay, and recorder.

Each one of these principal units performs a separate function, but all functions are closely coordinated to hold specimen temperature uniform within 1 C; provide uniform heating and cooling with the specimen in an inert atmosphere; automatic shutoff; and an overall accuracy of 0.2%. Accommodating 3-, 4-, or 5-in. specimens, the dilatometer will accommodate temperatures up to 1000 C.

● The *Fearless Tool Co.,* 1234 So. Gramercy Place, Los Angeles 6, announces the production of a new cutting tool. Known as the Shearcutter, it is a boring, turning and facing tool with a precision tool holder, for use on lathes, screw machines, drill presses and boring machines.

Light Materials Testing Machine Has Four Capacities

The *W. C. Dillon & Co., Inc.,* 5410 W. Harrison St., Chicago 14, announces a testing machine expressly built for lighter materials or small finished items. It has 4 separate capacities, each shown individually on its large dial. These ranges are: 0 to 10 lb. in 1-oz. dial divisions, 0 to 25 lb. in 2 oz., 0 to 50 lb. in 4 oz., and 0 to 100 lb. in 8 oz.

Its lower grip travel is continuously variable, or stepless, from 0 in. to 19 in. per min. It also has: ½ of 1% accuracy, pendulum action, maximum-load reading, featherweight and swivelled under grip, stroke limiting switches, forward-reverse switch, elongation gage, and stress-strain recorder. Overall height is 63 in., net weight 162 lb.

News of

Engineers — Companies — Societies

(Continued from page 818)

S. Western Ave., Chicago, in the building used by Foote Bros. Gear Works during the war. The new laboratory will include a machine shop, a gray iron foundry, a metallurgical laboratory, an X-ray laboratory with a million-volt machine, and similar departments. Cost reduction studies will be made at the new laboratory, and officials will set up manufacturing standards and standardized methods.

The *Indiana Steel Products Co.* is erecting an ultra modern plant in Greenburgh, N. Y., for production of special products in the permanent magnet field. The company has also purchased the *Cinaudagraph Corp.*, Stamford, Conn.

That portion of *Alloys Development Corp.*, Pittsburgh, owned by Mrs. B. D. Saklatwalla, widow of the developer of "Cor-ten" and other alloy steels, was sold to Frederick D. Foote and John Latta, associates of the late Dr. Saklatwalla. The sale was conducted at a session of the U. S. Court at Pittsburgh, presided over by Francis M. Turner, vice president, *Reinhold Publishing Corp.*, acting as special master.

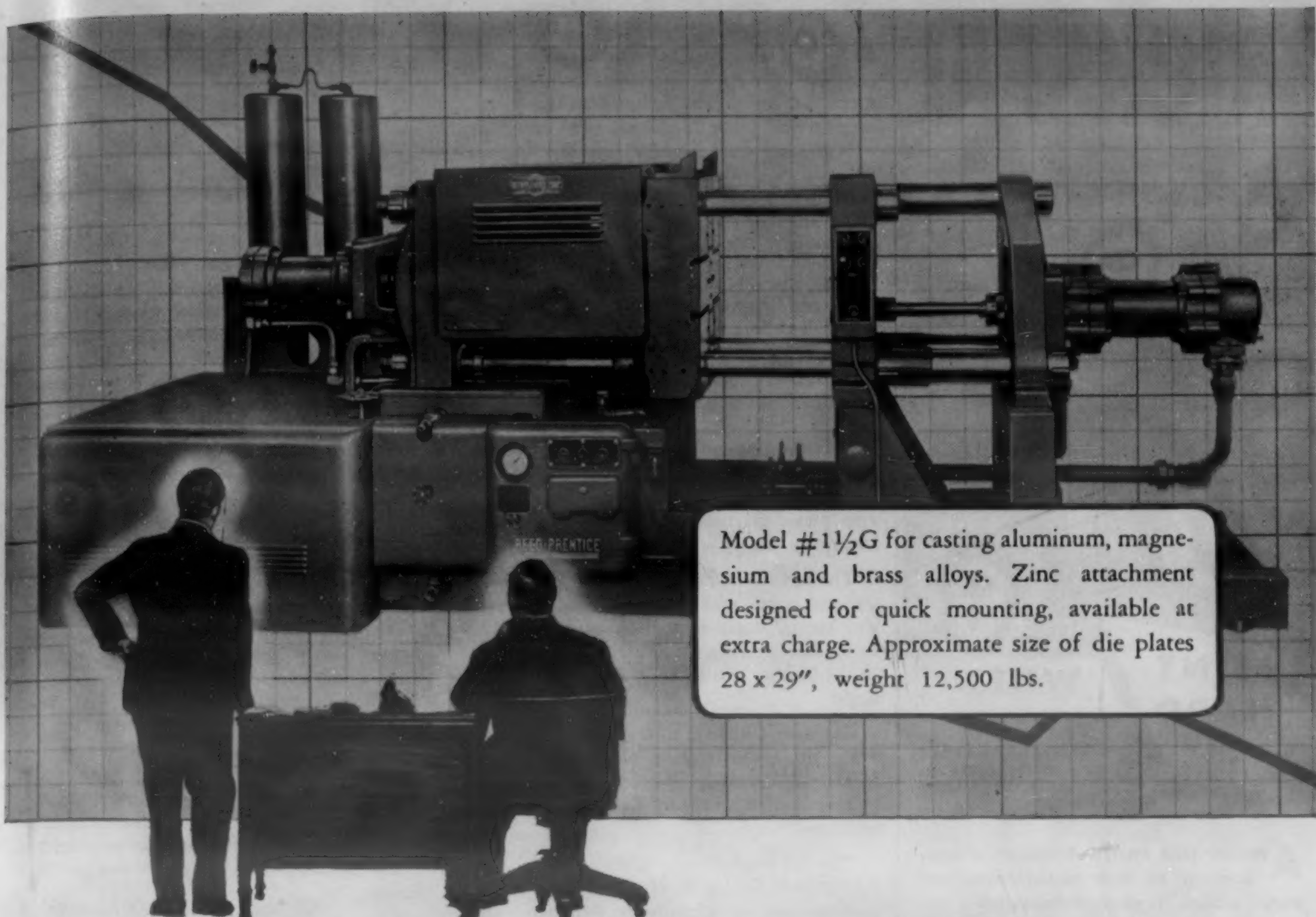
Extensive expansion will take place over the next two years at the Fairfield, Ala., sheet mill of the *Tennessee Coal, Iron & Railroad Co.*, Birmingham. The object is to convert the company's present hot-rolled method to the cold-reduced method of producing sheets. Also, provision will be made for the production of galvanized sheet metal in coils.

About 1,100 tons of steel for an atom smashing cyclotron will be made at a Pittsburgh plant of the *Carnegie-Illinois Steel Corp.* Some of the forgings will be so huge that special freight cars will be necessary to transport them to the University of Rochester, the final site for the atom smasher. The cyclotron will be owned by the Navy. It will produce particles of more than 200,000,000 electron volts.

A 2,000,000-volt X-ray machine will be installed by the *Babcock & Wilcox Co.*, at Barberton, Ohio, the first use of a machine of that size for examining welds in pressure vessels. It can be used on steel walls, 10 in. thick.

The *General Electric Co.* has started production at Coshocton, Ohio, of the largest and most modern plastics laminating plant in the country. It will contain shortly over 100 presses, the largest of 5000-ton capacity, capable of producing laminated sheets 50 x 100 in.

The *Bassick Co., Div. of Stewart-Warner Corp.*, maker of powdered metal parts, automotive hardware, etc., has bought an 8-acre tract containing 11 buildings at Bridgeport, Conn.



Model #1½G for casting aluminum, magnesium and brass alloys. Zinc attachment designed for quick mounting, available at extra charge. Approximate size of die plates 28 x 29", weight 12,500 lbs.

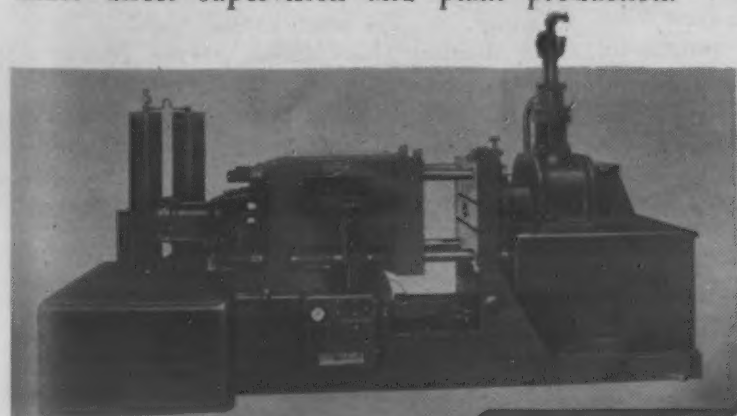
Cost Conscious Manufacturers are looking to DIE-CASTING!

War-time production experience effectively demonstrated that Reed-Prentice die casting machines save time and money — are economical and accurate!

Many alert manufacturers are now casting lighter-weight, important product-parts from aluminum, magnesium, zinc, tin, brass and lead base alloys — the modern way — under direct supervision and plant production.

When re-designing or planning new part specifications, it will pay to investigate the complete Reed-Prentice die casting machine line. In addition to the 1½G and 1½ models (illustrated), the 3G High Pressure Cold Chamber machine is available for larger capacity die casting from aluminum, magnesium or brass alloys and the #3 for casting from zinc, tin or lead base alloys. Approximate size of die plates 30 x 30", weight 24,200 lbs.

Mail Coupon NOW for full information!



Model #1½ for casting zinc, tin or lead base alloys. Cold chamber attachment for aluminum, magnesium and brass alloys, designed for quick mounting, available at extra charge. Approximate size of die plates 28 x 29", weight 15,500 lbs.

Reed-Prentice Corp.
Dept. P,
Worcester 4, Mass.

Please send full information and literature on Reed-Prentice die casting machines as checked below:

........Model #1½G ....Model #1½ ....Model #3G

NAME........

ADDRESS........

DIE CASTING
REED-PRENTICE CORP.
WORCESTER MACHINES MASS., U.S.A.

NEW YORK OFFICE: 75 West St., New York 6, N. Y.

CLEVELAND OFFICE: 1213 W. 3rd St., Cleveland 13, Ohio.

Gas Atmospheres, Inc., 20011 W. Lake Rd., Cleveland 16, has been recently organized with A. A. Straub as president, to specialize in gas atmospheres in the metallurgical and other industries. The company will design, manufacture and sell various types of equipment, including that for deoxidizing, carburizing, malleablizing, inerts, nitrogen, dissociated ammonia and hydrogen.

Theodore A. Cohen, nationally known electronic engineer, lecturer and technical writer, has formed his own company, *Taco Engineering Co.,* 2620 S. Park Ave., Chicago. The company is a consulting, designing and manufacturing one, specializing in electronic and electromechanical automatic control equipment for industrial process control and automatic machine processes. Previously, Mr. Cohen was founder and vice president-chief engineer, Wheelco Instruments Co.

The *Lake Erie Engineering Corp.,* Buffalo, designer and maker of hydraulic presses and special machinery, has taken over the Feller Engineering Co., Pittsburgh, specialist in hydraulic extrusion presses and allied lines.

Carboloy Co., Inc., Detroit, has introduced a 25-min. sound motion picture, "Everyday Miracles", dramatizing recent contributions to industrial progress by Carboloy cemented carbide.

The *General Bronze Corp.* will build a $2,000,000 factory in Hempstead, L. I., for manufacture of aluminum windows, aluminum screens, domestic heating units, etc.

Novel construction will feature electrically-shielded research laboratories for the *Federal Telephone & Radio Corp.,* Nutley, N. J. The walls consist of prefabricated panels made of a flat sheet of aluminum and a fluted sheet of steel, with a 1½-in. blanket of Fiberglas insulation between them. The walls, 3½ in. thick, have a heat insulating value equal to a 12-in. masonry wall.

The name of the *Sterling Tool & Stamping Co.,* Chicago 25, has been changed to *Frederick Products, Inc.* A new plant and enlarged staff of engineers are useful additions.

A new company, the *Protoform Co.,* has been formed at 212 W. 68th St., New York 23, to promote the "Protoform" process for speedy manufacture of precision molds by compacting any of several low melting metals and alloys. It is claimed that the mold will match the conventional steel die as to sharpness of definition and precision reproduction, the cost being virtually negligible. These molds and dies are for casting plastics, waxes, etc., and for making castings for prototype, short-run jobs.

Societies

Dr. Edgar C. Bain, vice president in charge of metallurgy and research, Carnegie-Illinois Steel Corp., will receive the Albert Sauveur Achievement Award for 1946 for his new approach to the heat treatment of steel.

Membership in the *American Foundrymen's Assn.* has more than doubled since 1941 and on June 30 was at a new high of 8,539 companies and individuals. Foreign memberships, excluding Canadian, gained 92% to 392 during the year. The Association plans a 5-point objective and, in addition, will campaign for more interest in the foundry as a work place, appealing to young men of school age. It is suggested, too, that interest be stimulated among faculty and students of schools.

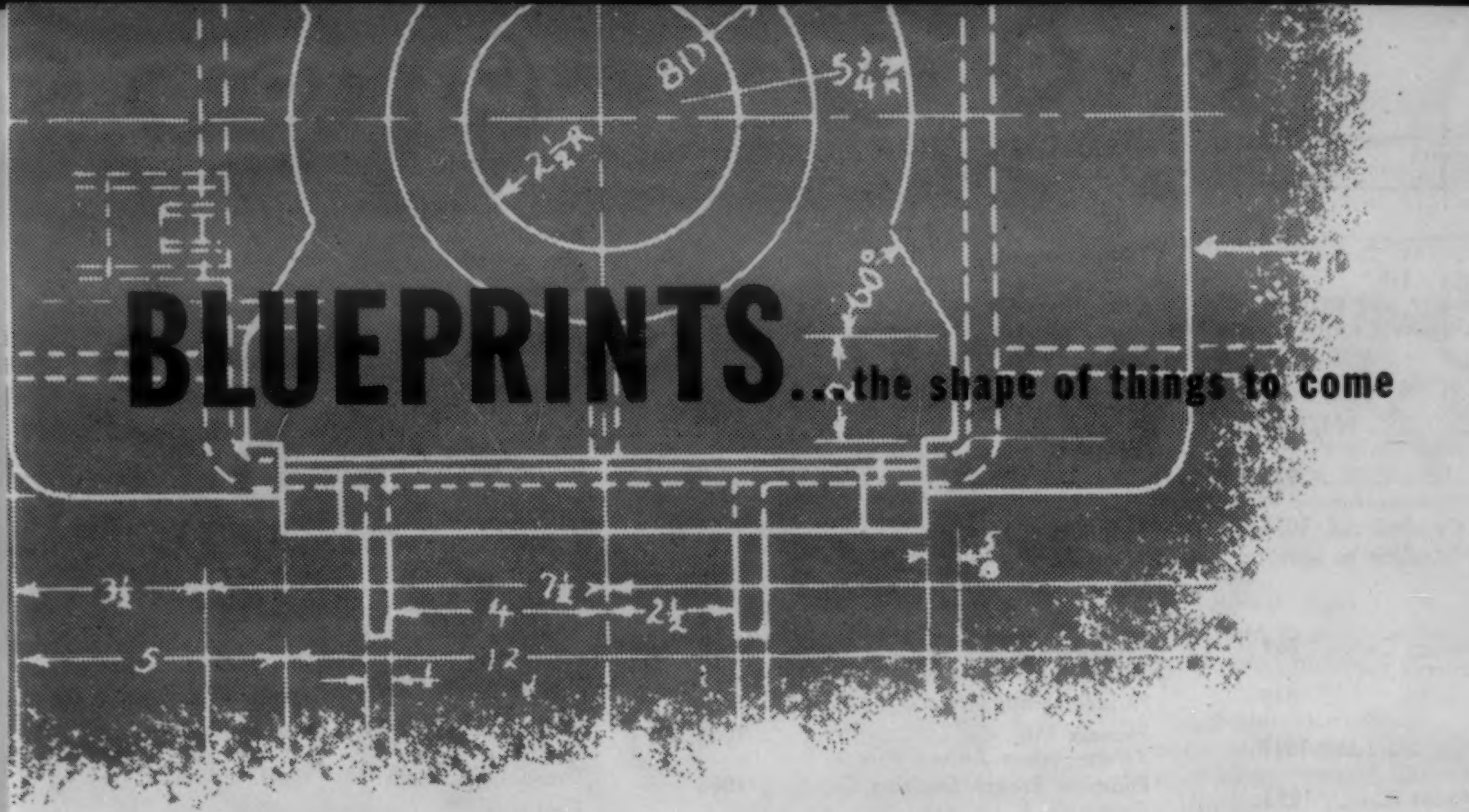
The *National Assn. of Corrosion Engineers* will hold its annual convention in the Palmer House, Chicago, April 7-10. There will be symposiums on water, electrical, chemical, communications, gas, oil, cathodic protection and general. The executive secretary is Elton Sterrett, 905 S. Standard Bldg., Houston 2, Texas.

The *American Society for Metals* has named Dr. Rufus E. Zimmerman of U. S. Steel to receive its medal for the Advancement of Research for 1946. . . . The *Metal Powder Assn.* has revised its standard for the tentative method for sieve analysis of granular metal powders, as of June, 1945, the revised standard being known as M.P.A. Standard 45-46T. . . . The *Malleable Founder's Society* has elected as its president Frank E. Shumann, Lehigh Foundries, Inc., Easton, Pa.

The *Society of the Plastics Industry* will hold its national plastics show at the Coliseum, Chicago, the week of May 5. It will display new plastics from all over America and captured German plastics products. Meanwhile, the *Low-Pressure Div., SPI,* will hold their second conference and exhibit at the Edgewater Beach Hotel, Chicago, Jan. 23-26.

The *Plating Institute,* Dime Bldg., Detroit 26, has established a committee of experts to assist manufacturers in selecting the type of plating, rustproofing or metal finishing best suited to their purpose. . . . *Battelle Memorial Institute,* Columbus 1, will appoint a limited number of graduate research fellows and postdoctoral research associates to do research in Battelle laboratories. . . . The tenth annual *National Time & Motion Study Clinic of the Industrial Management Society* will be held Nov. 7 and 8 at the Continental Hotel, Chicago. Inquiries may be sent to 176 W. Adams St., Chicago 3.

J. E. Arthur, Crucible Steel Co. of America, has been made president of the *Electric Metal Makers Guild, Inc.,* Pittsburgh . . . . The *American Society of Body Engineers, Inc.,* Detroit 2, has issued three pages of speakers for their convention Oct. 23-25 . . . . The *Electrochemical Society* has awarded the Edward Goodrich Acheson Gold Medal and $1000 to Prof. H. Jermain Creighton of Swarthmore College . . . . The World Conference on Mineral Resources by the *A.I.M.E.* has been postponed until March 17 . . . . The *American Society for Metals* has granted a charter to 37 technical men in the atom bomb project, to be the Los Alamos (N. M.) chapter.



BLUEPRINTS...the shape of things to come

New Lead Alloy for Phone Sheaths

Expect to hear soon considerable about an improved lead alloy for the flexible tube that stretches from one telephone pole to another, enclosing a group of wires. It is an arsenical lead, containing small amounts of tin and bismuth. It is suitable for underground installations as well as suspension above ground. The sheathing is characterized by strong, tough welds, outstanding resistance to bending fatigue, has excellent creep resistance and bursting strength. A successful cable, they say, depends more on the sheath than the insulation.

"Rigidized" Metal

You will be seeing much decorative and patterned aluminum and stainless steel in coming months that is stronger, pound for pound, than the plain metal strip. Thus, in bus seats we will find this "rigidized" metal as backs and kick plates. Besides being stronger, it does not show scratches and is pleasing to the eye because of two tones due to light reflection. It can be given a pattern to simulate a 3-dimension effect. As radio grilles over loud speakers it is more effective than cloth. Corrugated metal has strength along one axis; "rigidized" metal, along several axes.

Aluminum Axles for Heavy Trucks

Post-war testing has revealed the feasibility of heavy duty truck rear axles having aluminum housings, hubs and brake shoes, thus weighing 220 lb. less than conventional units. This vital weight economy is at a critical point below the springs and will lengthen tire life.

Printed Silver Circuits

From techniques developed in the manufacture of the proximity fuse, used so successfully late in the war to explode shells close to its target, useful peace-time applications are looming, such as miniature radio receiving sets. A feature is the "printing of the circuits." Instead of the conventional copper wire, connectors of metallic silver are imprinted on steatite plate by the silk screen method of stenciling. The silver is laid down as a paste containing either finely divided metallic silver or silver oxide, with binders and solvents to suspend the metallic ingredient. Watch our feature article section in a future issue for further details.

Ball Bearings in Watches

The marked advance in manufacture of ball bearings during the war is being reflected in new and novel peace-time uses, such as the ball point fountain pen that writes several years without refilling. A watch manufacturer is now experimenting with miniature ball bearings in place of jewels. In the future a good watch may have "17 balls" instead of "17 jewels."

New Die Steel for Brass Die Castings

The 16 chromium, 25 nickel, 6 molybdenum alloy steel developed and extensively used during the war for stressed parts of gas turbines and turbo-superchargers operating at up to 1500 F has been used as dies for die casting of brass. Results to date are "spectacular." Previously, with standard die materials short life and high cost made for small use of brass die castings. If the 16-25-6 "super alloy" turns out to be "super" for brass die castings it might revolutionize that industry.

Super Conductor for Electricity

One may expect some practical use for a recent discovery of super electrical conductivity materials, where the transmission loss is negligible. There are already some 35 such superconductors, but they function only if their temperature is held to within a few degrees of absolute zero, which is minus 273 C. Now materials have been discovered which are superconductive at minus 85 C. They are liquid ammonia solutions of alkali metals (lithium, sodium and potassium) and alkaline earth metals (barium, calcium and strontium). Here electrons are trapped in spherical mic cavities. Usually two electrons are held gether by two atomic nuclei, whereas these new solutions the electrons hold gether without the nuclei.

Shaft of Magnesium

A magnesium company is attempting develop a new shaft of magnesium will transmit the same amount of pow as the conventional shaft, but have mu less weight, hence adaptable to mobil power plants.

Cementing Rubber to Machinery

A German process for cementing rubb mountings onto steel machinery parts eliminate vibration and reduce noise wi probably be used here. The Germans u it in submarines to avoid detection. Tw methods of bonding were used: (1) dire application of the cement to degreased an sandblasted steel, employed for pieces to b used in compression, and (2) brass platin of the steel, followed by the cementing, em ployed where there was shear or torque.

Wire From Centrifugal Castings

A maker of metal screening from copp and its alloys has developed a novel metho of making flat wire of brass, phospho bronze and nickel silver, which may well b followed by others. The molten metal cast centrifugally into a thin disk. The cutting machines snip off the flat wires fro the outer edges of these disks. Advantage are sounder metal, free from flaws and g holes, hence with lower scrap loss. Th above three metals used do not require hea treatment.

Durable Brown Pigments

Brighter and more durable shades o brown color pigments for industrial enam els, trim paints, textiles, wall paper, etc. have been undergoing field tests satisfac torily. This new "auric brown" shows f less tendency to "chalk" from exposur than standard iron oxide pigments.